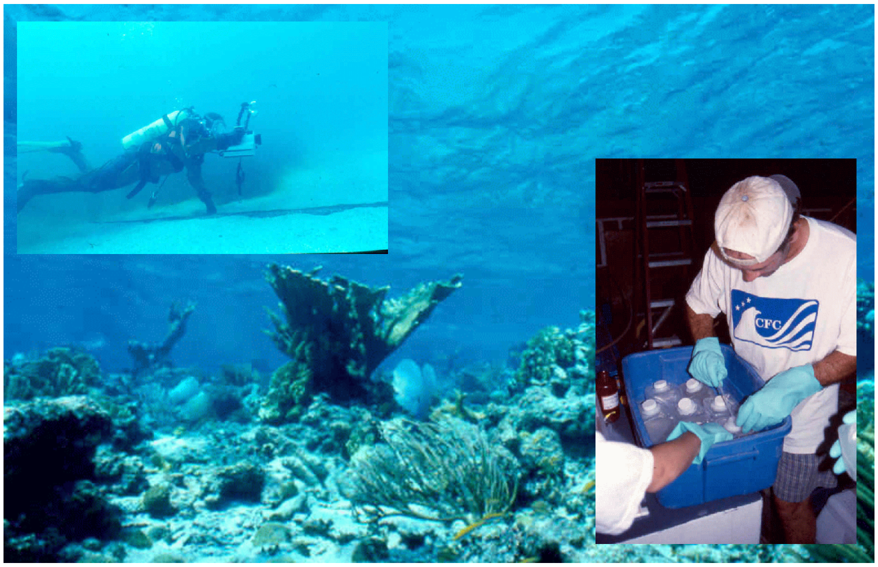
Technical Memorandum to the Record for Virgin Islands Rum, Industries, Ltd (VIRIL),

Subject: Ambient Ocean Monitoring Survey VIRIL Ocean Discharge



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U.S Environmental Protection Agency
Region 2

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APPENDIX

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Acronyms

BOD	Biochemical Oxygen Demand
CBERA	Caribbean Basin Economic Recovery Act
COD	Chemical Oxygen Demand
CSI	Compliance Sampling Inspection
CWA	Clean Water Act
DO	Dissolved Oxygen
DPNR	Department of Planning and Natural Resources
EPA	Environmental Protection Agency
GPS	Global Positioning System
H^2SO_4	Sulfuric Acid
IC50	Inhibition Concentration 50%
LC50	Lethal Concentration 50%
NEIC	National Enforcement Investigations Center
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephalometric Turbidity Units
OSV	Ocean Survey Vessel
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
RHIB	Rigid-Hulled Inflatable Boat
SAV	Submerged Aquatic Vegetation
TOC	Total Organic Carbon
TPDES	Territorial Pollutant Discharge Elimination System
USVI	United States Virgin Islands
VIRIL	Virgin Islands Rum Industries, Ltd.
WQC	Water Quality Criteria
WQS	Water Quality Standards

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Executive Summary

Virgin Islands Rum Industries, Ltd. (VIRIL) is a rum manufacturing facility located in Fredericksted, St. Croix, U.S. Virgin Islands. The rum manufacturing process generates wastewater that is discharged to the ocean via a discharge pipe on the south coast of St. Croix. The pipe's outfall is located on the ocean bottom in Negro Bay, approximately 1,900 feet from the shore at a depth of approximately 18 feet. The effluent typically forms a visible plume that starts at the discharge point and travels 5.5 to 6 miles westward, following the shoreline, approximately 2,000 feet from shore. The plume disappears at a position south of the tip of Sandy Point located on the western edge of St. Croix, where the shallow shelf drops off to depths exceeding 600 feet.

VIRIL's process wastewater is composed of sugars, organic acids, amino acids, proteins, polysaccharides, and inorganic salt complexes, and has historically been characterized as having an extremely high BOD and COD, thus is very low in dissolved oxygen. Additionally, it has been shown to be toxic to mysids, with measured LC50 values of less than 10 percent effluent.

VIRIL's discharge is regulated by the Virgin Islands Government by means of a Territorial Pollutant Discharge Elimination System (TPDES) permit. The Caribbean Basin Economic Recovery Act (CBERA), passed by Congress in 1983, exempts this discharge from certain portions of the Clean Water Act (CWA). Specifically it exempts the facility from effluent limitations (Section 301), national standards (Section 306), and ocean discharge criteria (Section 403), as long as specified conditions are maintained. Among those conditions is the determination, by the Governor of the Virgin Islands, that the discharge will not interfere with attainment of water quality in the receiving water as specified in CBERA. To date, affirmative determinations have been made by the Virgin Islands Government, that the discharge is meeting this water quality condition.

The U.S. Environmental Protection Agency (EPA), in cooperation with the U.S. Virgin Islands Department of Planning and Natural Resources (DPNR), conducted an ocean monitoring survey in the coastal waters along the south shore of St. Croix, USVI. This survey, conducted in February 2002, was focused on the wastewater discharge from the VIRIL production facility. The survey was designed to characterize the receiving waters directly influenced by the discharge in order to assist the Virgin Islands Government in making determinations on the VIRIL discharge required by the CBERA exemption.

Field sampling and observations were performed to characterize water quality and biological conditions throughout the area observed to be influenced by the plume. A grid of sampling and observation stations was established in the receiving water area that is typically exposed to the discharge plume, and in two areas that represent background conditions outside the influence of the discharge. Water quality was profiled throughout the entire depth for light penetration, dissolved oxygen, pH, temperature, and salinity. Water samples were analyzed for biological oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), nutrients, and aquatic toxicity. Sea grass samples were also collected for biomass analysis. Outside of the

grid, a set of sampling and observation stations in areas of coral presence was established for assessment of possible impacts to coral reefs.

The 2-week effort to collect environmental data provided a snapshot characterization of physical, chemical, and biological conditions occurring in this coastal system at that time. The results indicate a potential for negative impacts to the coastal environment influenced by the VIRIL discharge. A summary of the significant conclusions follows.

1. A thorough examination of water quality did not identify any significant water quality issues, including depletion of dissolved oxygen. However, although oxygen depletion was not detected in the condition of high mixing present during the survey, there is a potential for the high BOD of the effluent to cause a biologically adverse oxygen content in the receiving water during conditions of low mixing.

2. There is significant acute and chronic toxicity in the receiving water due to discharge of the VIRIL waste.

3. There is a strong turbidity and color attribute of the VIRIL discharge. This presents a potential for a critical adverse light-attenuating condition that could impede normal growth of submerged aquatic vegetation (SAV), such as turtle grass, in a significant area of the receiving water.

4. There appears to be a diminished abundance of SAV within the influence of the plume, which yields a potential to alter critical benthic habitat for endangered species, and both commercially and biologically important species.

5. There are no significant coral reefs identified within direct influence of the VIRIL discharge.

MEMORANDUM TO THE RECORD FOR: Virgin Island Rum Industries Ltd. (VIRIL)

SUBJECT: Ambient Monitoring Survey of the VIRIL Ocean Discharge

DATE: November 19, 2003 [Original: November 4, 2003]

FROM Charles LoBue
Dredged Material Management Team
Division of Environmental Planning and Protection
EPA Region 2

1. INTRODUCTION

The U.S. Environmental Protection Agency (EPA), in cooperation with the U.S. Virgin Islands Department of Planning and Natural Resources (DPNR), conducted two ocean monitoring surveys in the coastal waters along the south shore of St. Croix, USVI. These surveys, conducted in November 2000 and February 2002, were focused on the ocean discharge of the rum production facility belonging to the Virgin Islands Rum Industries, Ltd. (VIRIL). The surveys were designed to characterize the receiving waters directly influenced by the discharge, particularly with regard to specific exemptions from the Clean Water Act (CWA) maintained by VIRIL under the Caribbean Basin Economic Recovery Act (CBERA).

The surveys were conducted by technical staff from both EPA and DPNR. Basic operations were staged from EPA's Ocean Survey Vessel (OSV) PETER W. ANDERSON and assisted by the DPNR Water Pollution Control boat. The November 2000 survey collected basic information that was used for a preliminary assessment of the discharge and receiving water. As a preliminary assessment, the survey served to establish basic questions and hypotheses which were to be addressed in the February 2002 survey. Findings of the November 2000 survey were presented in a technical memorandum prepared on May 17, 2001, subject: *Ambient Monitoring of Virgin Island Rum Industries Ltd. Ocean Discharge*. (Appendix, Attachment 1)

This followup survey (February 2002) was designed to provide more definitive measurements and assessments, and to answer specific questions relating to the VIRIL's conformance to the conditions of the CBERA exemption. This report will present results and conclusions from information and data gathered by the field monitoring, sample analyses, and observations completed in the February 2002 survey.

2. BACKGROUND

VIRIL is a rum manufacturing facility located in Fredericksted, St. Croix, U.S. Virgin Islands. The rum manufacturing process generates an effluent that is discharged to the ocean via a discharge pipe on the south coast of St. Croix. (Figure 1).

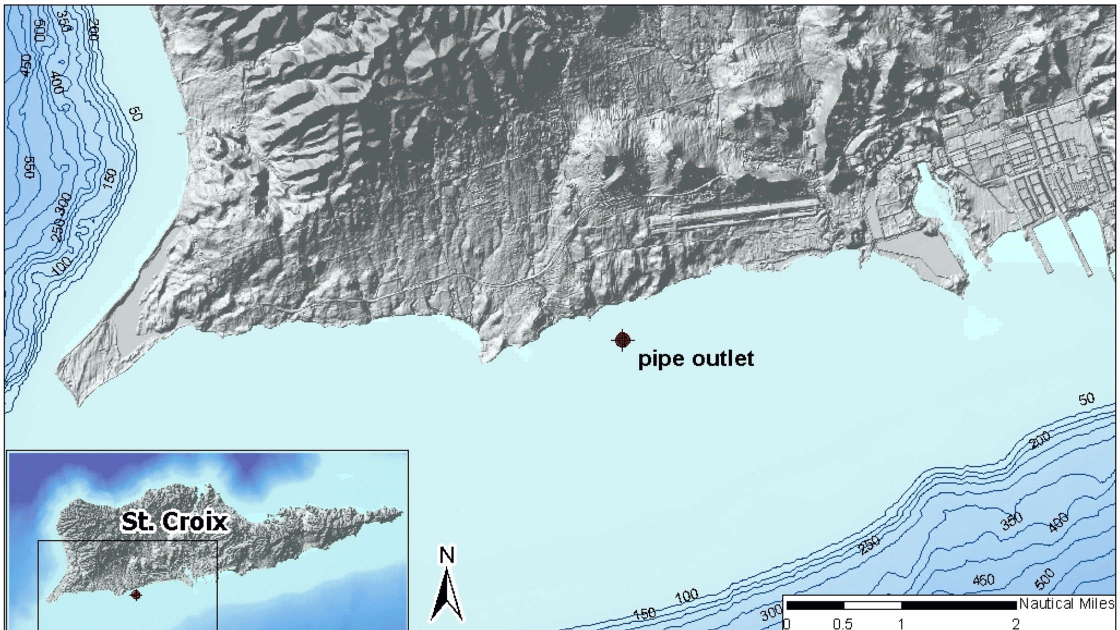

Figure No. 1: End of Pipe

In general, the coastal ocean on the south side of St. Croix in the region surrounding VIRIL can be characterized as a broad shallow shelf extending out to about one half mile off shore. The shelf slopes very gently to the south to depths of about 30 to 60 feet (9 to18 meters) at the drop off. Prevailing ocean conditions produce a mild westerly flow direction. The majority of the shelf can be described as sandy bottom, with scattered patches of coral reef.

The effluent is discharged from an outfall located on the ocean bottom in Negro Bay. The effluent is discharged from the end of the pipe that is located 1,900 feet from the shore at a depth of approximately 18 feet. Historically, process wastewater has been discharged at a rate of about 110,000 gallons per day, including fermentor bottoms, characterized as being composed of sugars, organic acids, amino acids, proteins, polysaccharides, and inorganic salt complexes. High levels of these organic materials are believed to contribute to high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in the wastewater.

The effluent has been characterized as having an extremely high BOD and COD, thus is low in dissolved oxygen. Additionally, it has also been characterized as highly toxic to mysids, an appropriate sensitive marine crustacean testing organism, with measured LC50 values of less than 10 percent effluent. The effluent typically forms a visible plume that starts at the discharge point at the outfall and travels 5.5 to 6 miles westward, following the shoreline, approximately 2,000 feet from shore. The plume disappears at a position south of the tip of Sandy Point located on the western edge of St. Croix, where the shallow shelf drops off to depths exceeding 600 feet.

The discharge is regulated by the Virgin Islands Government. At the time of the 2000 and 2002 surveys, the Territorial Pollutant Discharge Elimination System (TPDES) permit specified the following limits on the effluent discharged:

daily maximum flow of 115,000 gallons;

temperature of 48ºC (effluent temperature may be as high as 65ºC for not more than 96 hours per month);

COD of 50,000 kilograms per day.

CBERA, a Federal law signed in 1983, contains the following provision exempting VIRIL from certain portions of the Clean Water Act (CWA):

"Any discharge from a point source in the United States Virgin Islands in existence on the date of enactment of this subsection which discharge is attributable to the manufacture of rum (as defined in paragraphs (8) of section 7652(c) of the Internal Revenue Service Code of 1954) shall not be subject to the requirements of section 301 (other than toxic pollutant discharges), section 306 or section 403 of the Federal Water Pollutant Control Act if-

1 such discharge occurs at least one thousand five hundred feet into the territorial sea from the line of ordinary low water from that portion of the coast which is in direct contact with the sea, and

2 the Governor of the United States Virgin Islands determines that such a discharge will not interfere with the attainment or maintenance of the water quality which shall assure the protection of public water supplies, and the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities, in and on the waters and will not result in the discharge of pollutants in quantities which may reasonably be anticipated to pose an unacceptable risk to human health or the environment because of bioaccumulation, persistency in the environment, acute toxicity, chronic toxicity (including carcinogenicity, mutagenicity, or teratogenicity) or synergistic propensities."

This provision applies uniquely to VIRIL. It exempts the facility from the effluent limitations (section 301), national standards of performance (section 306), and ocean discharge criteria (section 403). Affirmative determinations have been made by the Virgin Islands Government regarding this condition, most recently in August 2002 by Governor Turnbull, and previous to that, by Governor Schneider in July 1995.

November 2000 Survey

The goals of the preliminary survey were to document, where possible, conditions that would negatively affect the environment to the extent as to interfere with specific use and environmental requirements (e.g., protection and propagation of a balanced population of shellfish, fish, and wildlife) of the receiving water as specified in the exemption. At the time of the survey, actual plume properties and behavior were poorly understood, and the survey did not provide definitive documentation of significant environmental effects.

Basic operations of the survey included collecting water samples and performing water quality measurements of the receiving water at locations throughout the plume. Diving operations were also conducted to observe plume and pipeline conditions, as well as to provide general environmental observations. The survey was conducted during the period of November 4 to 9, 2000. During the survey, ocean and discharge conditions were not consistent with our understanding from the background information. Particularly, the typical wind conditions were reverse or absent, and the plume was not oriented in the typical east-to-west profile. This atypical plume profile confounded the established observation stations that were planned for areas west of the outfall. Thus, conditions were not conducive to acquiring complete documentation of such aspects as: fate and transport of the plume; propagation of balanced populations of fish, wildlife, and coral reefs; and unacceptable risk to human health conducting recreational activities in the vicinity of the plume. While complete documentation goals were not achieved, survey measurements and observations provided a preliminary assessment of plume properties and environmental conditions, which enabled planning of a more definitive survey investigation.

Findings of the survey provided insight and understanding of the severity and variability of the plume. Water quality monitoring showed persistence of some characteristics of concern and excursions from Water Quality Standards (WQS) including:

> 52 dissolved oxygen measurements below WQS, (several at biologically significant levels)
> total phosphorous exceeding WQS
> odor producing substances

The turbidity was not measured to exceeded water quality standard using a secchi disk (water clarity observation tool); however, a severe turbidity condition, lower in the water column, was observed and identified as a potential threat that warranted further attention. The secchi disk WQS for turbidity is that the disk can be observed at a water depth of 1 meter (m) from the surface. In the area of the plume, the secchi disk was observed at depths well in excess of 1 m.

However the highly turbid plume was observed to be present at the bottom of the water column, where the secchi disk immediately disappears into the turbidity of the bottom of the water column. There is another WQS that measures turbidity, anywhere in the water column, using a turbidity meter (nephalometer). Nephalometer measurements were not performed during the November 2000 survey. Thus, the receiving water was not documented to exceed the WQS, while carrying a very dense turbidity feature that could be expected to cause a significant negative impact to ambient light and nutrient levels, and sensitive benthos because of its highly particulate and light attenuating nature.

Field observations from surface and diving operations provided evidence about the basic physical nature of the plume and environs. Physically, the plume exists in two fractions within the water column: a turbidity plume and a color plume. The turbidity plume is a thick plume of solids that runs along the bottom starting at the origin of the discharge. It was observed to be greater than 1-m thick, virtually opaque, and extending beyond the immediate vicinity of the discharge. The color plume is a dark discoloration of the water column that extends beyond the turbidity plume as far as the west shelf drop off. Sediments and corals in the far field were observed to be covered with a fluffy substance that did not appear to be of a standard sedimentary nature. With general regard to the environs, the coastal area seems to possess significant flora and fauna. Sea grass beds exist throughout, in areas up current, inshore, and offshore of the plume. The area also seems to be attractive to wildlife, as schooling fish, sharks, rays, sea turtles, etc. were observed.

The overall conclusions from the November 2000 survey were that the plume is oriented toward the bottom of the water column; the discharge failed to attain the water quality standards; the thickness, opacity, and color of the plume could negatively affect flora and fauna throughout the entire 6-mile distance to the west shelf; and that solids could be settling in far field coral areas. Therefore, there was a need for further study to define impacts. The reconnaissance characterized the plume as having three zones for future studies:

Immediate Vicinity: 0 to 20 m distance from the outfall (heavy solids plume)
Near Field: 20 - 1,000 m (mixed solids and color plume)
Far Field: 1,000 m to end of plume (~6 miles) (mostly color plume)

Details of the November 2000 survey are presented in *Ambient Monitoring of Virgin Island Rum Industries, Ltd. Ocean Discharge*. (EPA 2001)

Following the completion of the field work for the 2002 survey, the VIRIL TPDES permit was reissued with some changes. The flow limit was increased to 138,000 gallons per day; the COD limit was increased to 60,000 Kg/day; and a special condition was imposed which requires treatment (settling) of fermentor bottoms, followed by landfill disposal of solids.

3. FEBRUARY 2002 SURVEY

3.1 Overview

The discharge from VIRIL into the ocean off the southern shore of St. Croix, USVI is subject to CBERA. This act exempts it from a number of CWA provisions, as long as the Governor of USVI determines that the discharge satisfies the construction and water quality conditions written in the exemption. Aside from the November 2000 survey, little information has been gathered about the nature and effects of the VIRIL plume on the ecosystem. The February 2002 survey was conducted to provide a more comprehensive picture of the coastal area within the vicinity of the plume. The survey activities are intended to provide scientific knowledge about the plume and its effects, and to assist EPA and DPNR in decision making related to the CWA and CBERA.

The survey was conducted during the period of February 5 to 16, 2002. Six weeks prior to the survey, the discharge was stopped during the annual plant shut down. There was no discharge from the outfall for the interim six weeks prior to VIRIL restarting operations. On February 1, four days prior to startup of survey sampling and observations, plant operations were restarted and the wastewater discharge resumed. The survey was conducted using the OSV ANDERSON augmented by using the DPNR Water Pollution Control boat for water quality monitoring in the shallows. Field operations were performed by EPA personnel in cooperation with DPNR personnel. Sampling and observation activities were focused on sensitive receptors, and environmental targets selected to aid in making an assessment as to whether the VIRIL discharge plume is contributing to the decrease in the propagation of a balanced population of shellfish, fish, and wildlife (i.e., sea grasses and corals). Data collected were used to establish a baseline profile of plume conditions and the surrounding ecosystem with respect to the water quality, sediment quality, water toxicity, and biological condition.

3.2 Objectives

The survey was conducted to provide a more definitive assessment of conditions, and to judge whether the discharge plume from the VIRIL facility would negatively affect the environment to the extent as to interfere with specific use and environmental requirements (e.g., protection and propagation of a balanced population of shellfish, fish, and wildlife) of the receiving water as specified in the CBERA exemption.

A quality assurance project plan (QAPP) was prepared on January 29, 2002. The QAPP details project objectives and procedures (EPA January 2002). All work performed during this monitoring survey were in conformance with specifications defined in the QAPP. The primary objective of the survey is to provide an environmental assessment of coastal ocean conditions in the vicinity of the VIRIL discharge plume. The data collection was designed to gather physical, chemical, and biological data to develop an understanding of environmental and habitat conditions in areas within the influence of the plume, and to provide new insight on the environmental conditions off shore in relation to the CBERA exemption specifications. Observations and sampling focused on areas within the influence of the discharge plume, and in reference areas not believed to be affected by the plume or other industrial discharges. The data collected are spatially limited in that they are biased towards the plume and areas located in the vicinity of the plume. The specific monitoring tasks were as follows:

hydrographic profiling of water column for light penetration;
hydrographic profiling of water column for water quality parameters (temperature, pH, dissolved oxygen, and salinity);
analyses of receiving water samples for turbidity and color;
analyses of receiving water samples for biochemical and chemical oxygen demand (BOD) and (COD), total organic carbon (TOC), and nutrients;
testing of whole effluent for acute toxicity;
testing of receiving water samples for acute and chronic toxicity;
analyses of plume solids for particulate morphology comparison;
observation of sea grasses for impacts to productivity;
observation of corals for evidence of disease.

3.3 Basic Field Operations

Three basic field operations were: surface water quality monitoring operations, diving operations, and field analytical operations.

The surface water quality monitoring operations included the following activities:
hydrographic profiling for light penetration and water quality characterization; and
collection of water samples for turbidity, color, BOD, COD, nutrients, TOC, solids particle fingerprinting analyses, and toxicity testing.

Diving operations included the following activities:
sea grass sample collection for biomass characterization;
coral reef observation for disease characterization;
sediment sample collection for plume particulate morphology characterization; and
video documentation of the outfall area.

Field analytical operations included the following activities:
5-day BOD analyses; and
turbidity and color analyses.

The OSV ANDERSON was used as a platform for staging field laboratory operations, sample preparation, field analyses, diving operations, and staff scientist housing. The DPNR boat was used to perform the surface water quality operations.

3.4 Sampling/Observation Design

The monitoring scheme was based on two different biased, sampling designs: 1) a series of biased plume-focused transects throughout the actual observed discharge plume targeted to monitor the plume for water quality issues and other benthic biological impacts; and 2) an array of randomized and biased locations in far-field areas specifically targeted for presence of coral reefs.

3.4.1 Design for Plume-focused Transects

A series of transect locations was established based on the results of the November 2000 survey. These transects were designed to locate biased sampling and observation locations in and around the plume for collecting field measurements of light penetration and water quality parameters, and sampling for BOD, COD, TOC, eutrophication nutrients, sea grass observations, and acute toxicity tests.

Preliminary assessment of the information from the November 2000 survey characterized the plume as having three zones: immediate vicinity; near field; and far field. Transect lines, on which to locate five sampling/observation stations, were established to traverse the plume in all three zones and at selected reference locations.

Two transects were set up in the immediate vicinity, five transects in the near field, and five transects in the far field. Five stations for hydrographic profile measurement and sample collection were originally established at each transect. Each station was assigned a unique station number (alphanumeric) consisting of the transect identification, plus a sequential letter suffix (A-E), for its orientation within each transect across the plume starting at the northern terminal.

The prefix scheme is as follows:

- V - Transect designation for the immediate vicinity
- N - Transect designation for the near field
- F - Transect designation for the far field
- RA - Transect designation for the reference areas

The suffix scheme is set up as follows:

- "A"- Northern boundary;
- "B"- Midway between "A" and "C";
- "C"- Midway between the northern and southern boundary;
- "D"- Midway between "C" and "E";
- "E"- Southern boundary

The boundary locations were designed to be clearly outside of the plume so that water quality observations are taken in conditions in relatively clean water that brackets the plume target areas.

Although specific locations for each station were designated in the QAPP, the actual locations used for the hydrographic profiling and water quality sampling differed during the survey based on the actual position of the plume at the time of the survey. Stations for sea grass samples were maintained as close as possible to those locations planned, within the limits of available sea grass beds.

Transects were also set up in two reference areas. These reference areas were designed to represent ocean conditions from areas similar in physical oceanographic nature to those in the location of the plume, but outside the influence of the VIRIL plume. Data from the reference areas were used for comparison to various measurement/testing results from the plume measurements. Two locations were established to represent reference conditions: one within the local industrial influence (approximately 2.5 miles to the east); and one within a pristine vicinity (approximately 9.5 miles to the east). Both reference locations are up (prevailing) current from the outfall. The reference locations were selected using bathymetry charts and NOAA benthic characterization charts to represent environments of similar depth, benthic profile, sediments, and general current patterns. All reference transect locations are sand bottom areas along the south shore, within a mile from shore. All reference locations have partial coverage of sea grass and are in depths between 10 and 20 feet (ft). A gently flowing westerly current prevails in the reference areas as it does all along the south shore. Appendix Table A-1 lists the north and south boundaries of the planned transects.

The rationale for using biased monitoring locations within the observable plume is to focus efforts on documenting effects from the directly observable discharge feature. The planned locations of stations were based on surveillance data; actual locations used for monitoring and sample collection were determined in the field based on the conditions presented. Results from a biased or judgmental sampling design were used to make general characterizations of water column and biotic conditions throughout study area. Figure 2 depicts the expected plume track and designed study transects. Figure 3 depicts transects established in reference areas.

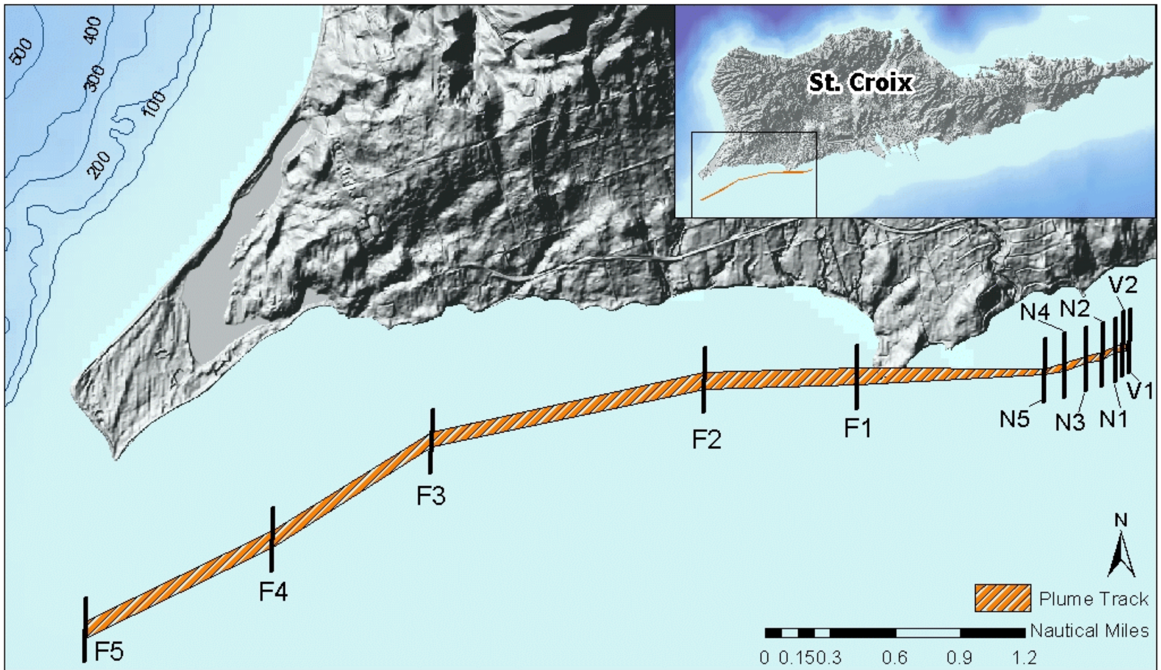

Figure No. 2: Transects and Projected Plume Track

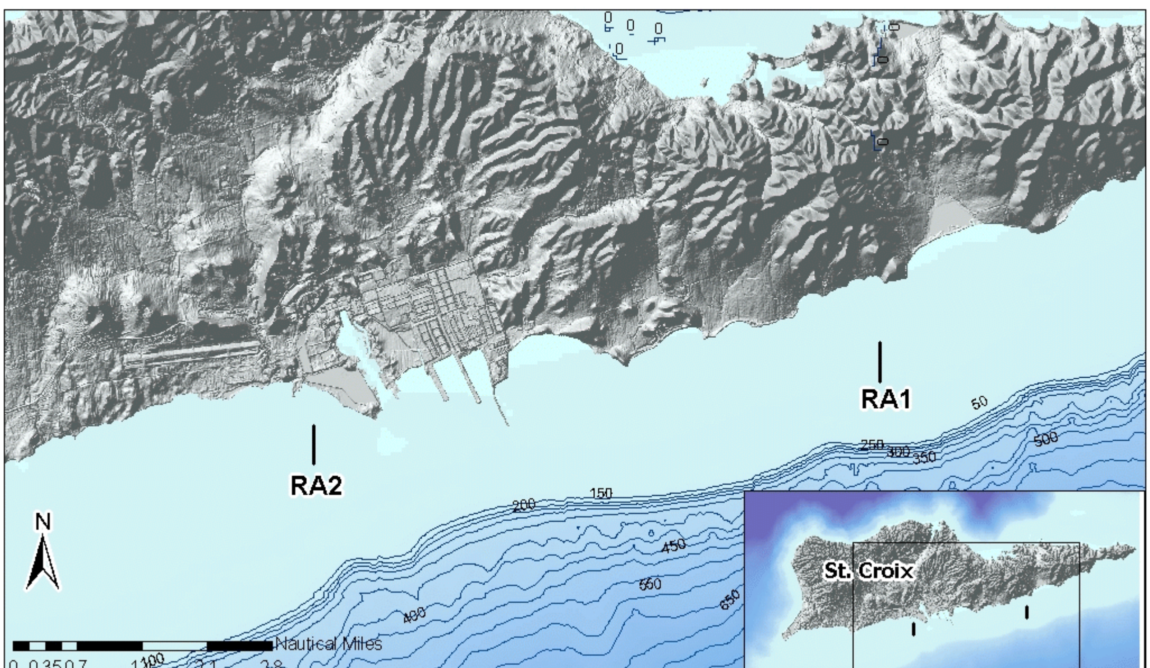

Figure No. 3: Reference Area Transects

3.4.2 Design for Coral Reef-focused Randomized and Biased Stations

In addition to the systematic grid design of the plume-focused transect array, general areas in the far field were identified as having coral stands. Stations were established in these locations to perform observations of coral disease and sampling of a particulate material that was observed on patch corals in the November 2000 survey, and appears to be not of a terrigenous nature. This nonterrigenous material appeared to have a light and fluffy consistency, unlike natural earthborne sediments.

For the coral disease observations, arrays of randomly located stations were established in three far field target areas of anticipated coral coverage and two coral background areas. The three target areas were selected to represent coral areas potentially influenced by the VIRIL discharge. The two background areas were designed to represent one up-current coral area of similar regional oceanographic influence, other than significant exposure to the plume, and one pristine coral area, far-removed from any local industrial exposure. Benthic habitat maps, produced by NOAA, were used to identify the potential coral locations. Each of the five station arrays was composed of 10 randomly positioned stations. Using a hexagonal (expressed in square nautical mile units (NM^2)) grid procedure, randomized samples were designed to be established wherever coral was present (Figure 4).

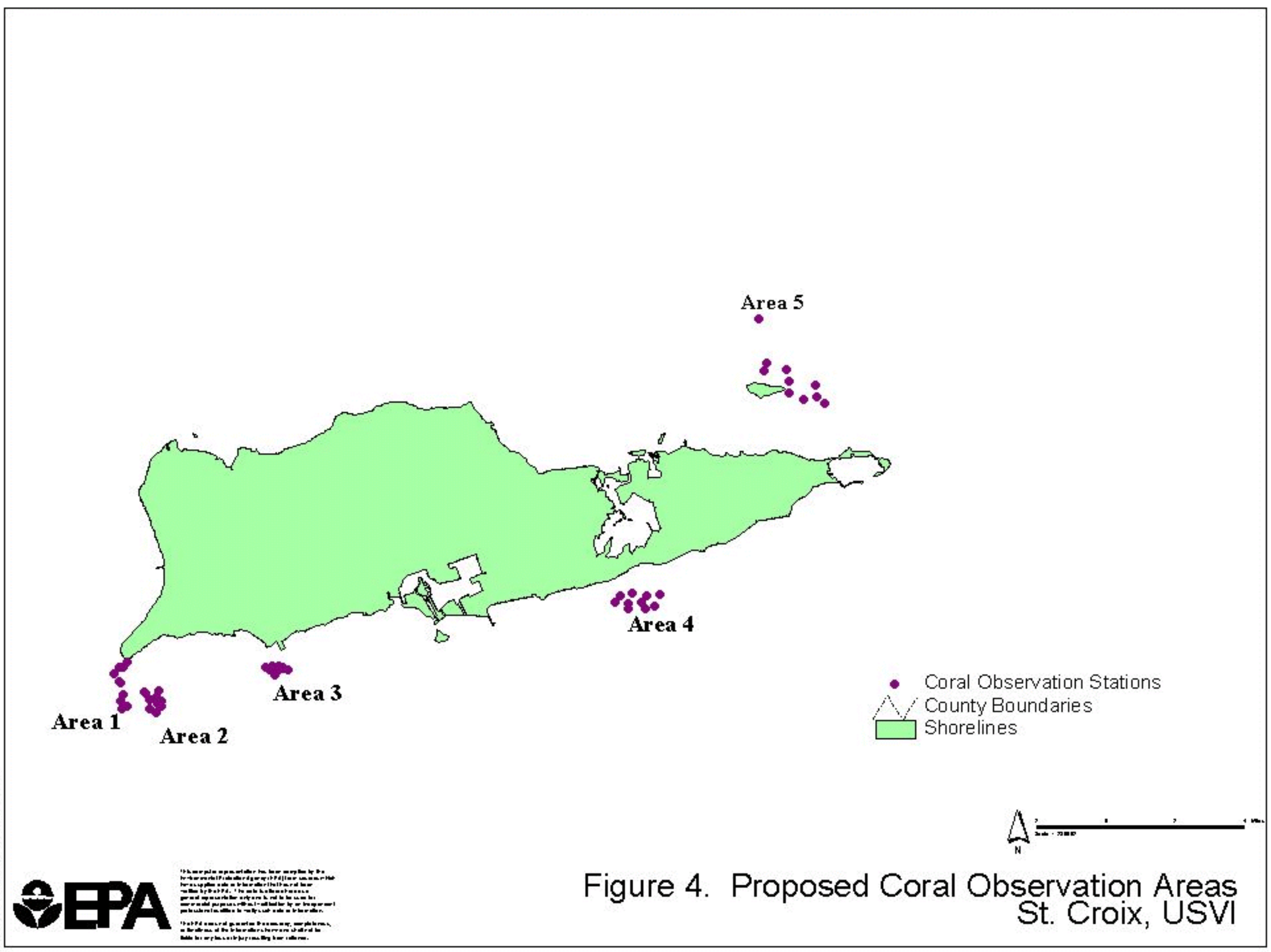

Figure 4. Proposed Coral Observation Areas
St. Croix, USVI

Locational information is provided in Appendix Table A-2. The basic design was to survey three 10-m-radial coral samples within each of the five areas. This would be achieved by starting at the first designated station and working through the ten, skipping those without adequate coverage, until three stations were observed. For the nonterrigenous particulate mat sampling stations, three far field stations were established based on observations made in the November 2000 survey.

3.5 Survey Methods

3.5.1 Plume-focused Water Quality and Biological Transect Survey

As described, a suite of specific survey operations were focused directly on conditions observed within the area of the prevailing plume. The critical effects-based assessment, sea grass growth, was focused on static benthic areas that receive the most significant long-term exposure, i.e., the areas of the typical plume profile. The hydrographic profiles of water quality and light penetration, water column toxicity, TOC, COD, nutrient, color, and turbidity analyses were focused on the dynamic water column of the actual plume. The survey was designed to link the analyses of these static and dynamic environments, and it was anticipated that minute-to-minute variation of the shape and orientation of the plume would result in locational variation in the actual water column monitoring activities performed at each designated station location. Thus, the hydrographic profile water quality monitoring and water sampling stations were located relative to the visible plume profile, and the stations for sea grass sampling were located at the coordinates originally planned, within limits of available sea grass beds, which were usually within the typical visible plume profile. A modification in the work planned is that three, instead of five, observation stations were monitored in the near field transects, because of the narrow width of the plume in the area near the discharge. Appendix Figure A-1 presents locations for the plume-focused observations and sampling stations. All location coordinates were identified using a Garmin GPS Map 182 tracking system. Spatial representations in this survey incur an uncertainty based on a GPS accuracy of about 3 m.

3.5.1.1 Hydrographic Profiling for Light Penetration and Water Quality

Ambient light and water quality measurements were performed using a Li-Cor light meter and HydroLab deployed from a small boat at stations presented in Appendix Table A-3: *Matrix of Sampling and Observation Locations*. Water quality was measured for temperature, pH, dissolved oxygen, and salinity. All measurements were recorded along with associated location coordinates.

Light, temperature, dissolved oxygen, salinity, and pH were measured at 1-m depth intervals at the designated station locations in the transect grid using a HydroLab minisonde instrument and a LiCor light meter. The probes for these two instruments were tethered together by binding the electronic lead lines together with electrical tape. One-m intervals were marked on the lead lines by using a light-colored water proof tape. Although five stations were planned for each transect, the narrow width of the plume in the near field warranted that only three stations be monitored in each of the near field transects.

Measurements were performed beginning at the surface and then proceeding down through the water column at 1-meter intervals until a depth within a meter of the bottom was recorded. To determine when the unit reached a depth within one meter from the bottom, the unit was lowered slowly until it stopped and the bottom was sounded. The unit was then slowly raised 1 meter and the measurement taken and recorded. All measurements, including location coordinates, were recorded onto field data sheets.

The LiCor light meter used a dual photo receptor probe that measured ambient light at the surface simultaneously with underwater light at each specific depth. Thus, transmittance of light through the water column could be calculated, independent of the variation of sunlight caused by cloud cover, by analyzing the depth light measurement as a percent of the ambient measurement. All measurements were carefully defined with regard to location using D-GPS position fixing and recorded on field data sheets.

3.5.1.2 <u>Water Sample Collection</u>

Sea water samples for turbidity, color, BOD, COD, nutrients, TOC, and plume particulate morphology analyses, that were collected for the designated locations are presented in Appendix Table A-3: *Matrix of Sampling and Observation Locations*. The samples were collected using a 2.2-liter (L) horizontal-profile Alpha bottle water sampler. The Alpha bottle sampling device was selected for use because of its horizontal orientation, which allows for the collection of a more focused sample at a specific depth. The 2.2-L model was used to efficiently collect the smaller sample volumes needed for the described parameters.

<u>Turbidity and Color</u> For each station designated for turbidity and color analyses, two sea water samples were collected: one from the surface, and one within 1 m of the bottom. Each sample was transferred from the sampling device into a 1-qt cubitainer. The color analyses were used to screen the water column for the vertical depth at which the color fraction of the plume exists. The samples were analyzed aboard the ANDERSON.

<u>Five-Day BOD, COD, TOC, and Eutrophication Nutrient</u> For each station designated for these analyses, one sea water sample was collected from the bottom depth approximately 1 m above the sea floor. The samples for BOD were cooled to 4º C, and analyzed aboard the ANDERSON. Samples for COD, TOC, nitrates, nitrites, phosphorous, and ammonia analyses were preserved with H^2SO_4 to pH<2 and cooled to 4º C for shipment. The samples were shipped to the EPA Region 2 Laboratory in Edison, New Jersey for analysis.

<u>Particulate Morphological Comparison of Solids of the Turbidity Plume</u> For each of the two Immediate Vicinity stations, one Near Field station and one Far Field station, one sea

water sample was collected from within 1 m of the bottom, within the solids plume. Sea water samples were collected using a 4.4-L horizontal Alpha bottle water sampling device. For each station, the water sample was transferred into two 2½-gallon (gal) cubitainers. The samples were cooled to 4º C, and shipped to the EPA NEIC laboratory in Denver, Colorado for analyses. Appendix Figure A-2 presents sample locations for particulate morphology analysis.

Sea water samples for toxicity bioassays that were collected at the designated locations are presented in Appendix Table A-3: *Matrix of Sampling and Observation Locations*. The samples were collected using a 4.4-liter (L) horizontal-profile Alpha bottle water sampler. The 4.4-L model was used to collect larger volume samples needed for the bioassay testing.

The sea water samples were collected, from the DPNR Boat, from two up current reference areas and the designated locations within the plume. For each station, the water sample was transferred into one 2½-gallon (gal) cubitainer. The samples were collected from depths either at or near bottom.

Effluent samples for toxicity bioassay testing were collected separately at the VIRIL facility effluent spigot directly into the sample containers in accordance with NPDES Compliance Sampling Inspection (CSI) procedures. Toxicity test samples from the facility and the study area were collected simultaneously on the specific days dedicated to this task. Since the laboratory received two separate batches of samples for the toxicity tests on the receiving water and the effluent, the reference locations were sampled on each of the two sampling days to accommodate appropriately comparable reference replicates for the batches. All acute toxicity samples were shipped via Federal Express overnight delivery to the EPA laboratory in Edison, New Jersey. Appendix Figure A-3 presents locations of receiving water samples for the toxicity testing.

3.5.1.3 Turbidity and Color Analysis

Samples collected in conjunction with the hydrographic profile survey were analyzed for turbidity in the ANDERSON's laboratory using a turbidity meter. Samples for color analysis were analyzed using a color wheel.

Turbidity analysis using a turbidity meter, as opposed to a secchi disk, is preferred because it results in a quantified description of the solids. The turbidity concentration is recorded in nephalometric turbidity units (NTU).

Color analysis was performed for field screening purposes, as color and absence of color was useful in determining the depth orientation of the color fraction of the plume. The color analysis was performed as a qualitative assessment of presence or absence.

3.5.1.4 Five-day Biolochemical Oxygen Demand Study

Receiving water samples were analyzed for BOD in the ANDERSON's laboratory by conducting a 5-day BOD study. A series of dilutions were performed on the sample with a nutrient buffer solution. The diluted samples were inoculated with an active microbial population and incubated in the dark at 20°C for 5 days. The bottles used were sealed to prevent adsorption of oxygen during the test. BOD was calculated from dissolved oxygen readings taken before and after the incubation period. (EPA 2002, SOP C-21). Analytical runs for the study were in batches of three to five stations at a time.

An effluent with high organic content can deplete the dissolved oxygen in receiving waters. BOD is a measure of the oxygen used by microorganisms to decompose a waste, whether it be sewage, manure, or food process wastes. When organic matter is present in water, bacteria begin the process of breaking down the waste. As the breakdown of the waste occurs, much of the available dissolved oxygen in the water is consumed by the aerobic bacteria, robbing other aquatic organisms of the oxygen needed for survival. The BOD results provide specific field information to determine the fate and dispersion of the high BOD source within the receiving water and potentially over critical environments and aquatic organisms.

Due to the space limitations inherent in field analyses, 60 ml BOD bottles were used in place of the standard 300 ml bottles used in the Edison laboratory. All reagent and sample volumes were reduced by a factor of 5, in accordance with EPA methods.

3.5.1.5 Chemical Oxygen Demand

Chemical Oxygen Demand (COD) is a measure of oxygen required to degrade the organic compounds in waste water. Receiving water samples were collected and shipped to the EPA Laboratory in Edison, New Jersey. Samples were digested for two hours with potassium dichromate, a strong oxidizing agent. Oxidizable organic compounds react reducing the dichromate (Cr+4) to green chromic (Cr+3) ion. The amount of dichromate remaining or the amount of chromic ion produced is measured colorimetrically to determine the oxygen demand.

The COD method determines the quantity of oxygen required to oxidize the organic matter in a wastewater sample, under specific conditions of oxidizing agent, temperature, and time. Since the test utilizes a specific chemical oxidation, the result has no definite relationship to the BOD or to the Total Organic Carbon (TOC) level of the sample. The test result should be considered as an independent measurement of organic matter in the sample, rather than as a substitute for the BOD or the TOC test.

3.5.1.6 Eutrophication Nutrient Analysis

The plume at VIRIL contains the byproducts of a sugar refining process and, as such, is of a nutrient nature. Nutrients such as nitrates and phosphates in a body of water can contribute to high BOD levels. Plant nutrients, such as nitrates and phosphates can cause rapid growth of plants and algae. Such rapid algal growth in an oligotrophic environment can alter the floral balance in sea grass beds and corals. This can lead to algal species outcompeting the sensitive and environmentally critical sea grasses and symbiotic coral algae, and proliferation of phytoplankton blooms, which could lead to reducing light penetration critical to a balanced benthic environment. Analyses of sea water for nutrients were performed to assess inputs of eutrophying agents, which are detrimental to the health of corals and sea grasses. Data from this analysis are intended to characterize the extent of possible migration of eutrophying nutrients to sensitive sea grass and coral areas.

3.5.1.7 Total Organic Carbon Analysis

Since high levels of organic materials in the wastewater are believed to contribute to its high BOD and COD, analysis for total organic carbon (TOC) were performed to provide supplementary information for the BOD and COD analyses.

3.5.1.8 Acute and Chronic Toxicity Testing

As evidenced during the 2000 survey, a broad expanse of ocean floor in the immediate vicinity of the outfall is covered by a 1-m thick water column layer of dense flocculent-appearing particulate matter. Acute toxicity tests have been performed on the whole effluent from the VIRIL facility. Toxicity has been consistently measured below 3 percent wastewater using the marine crustacean, *Mysidopsis bahia* and/or the silversides minnow, *Menidia* sp. A high oxygen demand was often present in those tests, as anoxic or hypoxic conditions were evident in samples diluted to less than one percent effluent. In general, the role of the oxygen demanding effluent on toxicity in the receiving water has not been estimated.

In order to measure potential impacts in the receiving water, acute and chronic toxicity tests were performed on undiluted ocean water samples collected in the vicinity of the VIRIL effluent discharge. The toxicity assessment also included testing of reference stations. The reference stations were ocean water samples in the vicinity but out of the area of influence of VIRIL wastewater. There were three types of toxicity tests: 1) an acute LC50 toxicity test on the whole effluent using fish and mysid shrimp; 2) acute toxicity tests on the whole receiving water using fish and mysid shrimp; and 3) a short-term chronic test on the whole receiving water using gametes of sea urchin.

Whole Effluent Acute and Chronic Toxicity Tests   Acute 96-hour toxicity tests, measuring the median effect concentration, were conducted using *M. bahia* and *M. beryllina*. Test organisms were exposed to a series of dilutions of the effluent. Since the objective is to isolate the toxicity from possible toxic effects from the plume, dilutions were made by mixing effluent with natural seawater collected from Manasquan, New Jersey. Mortality was the test endpoint and an LC50 value was calculated using appropriate statistical procedures. The sea urchin fertilization test is one of six short-term toxicity tests for estimating the chronic toxicity of aqueous samples published in the EPA toxicity manual, *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms,* 600/4-91/003. The method consists of exposing dilute sperm suspensions to effluent or receiving water samples for one hour. Eggs are then added to the sperm suspensions. Two hours later the test is ended by the addition of a preservative. Percent fertilization is determined by microscopic examination of a subsample from each treatment. The test endpoint is reported as the concentration of the test substance that causes a statistically significant reduction or increase in fertilization percentage (first cleave) as compared to a control or reference sample. The effluent dilution series used for acute testing of *M. bahia* and *M. beryllina* were also tested using *Arbacia punctulata*.

<u>Receiving Water Acute Toxicity Tests</u> Acute 48-Hour daily non-renewal toxicity tests were conducted on eight receiving water and two reference stations using the marine crustacean, *Mysidopsis bahia* and/or the silversides minnow, *Menidia* sp. Acute toxicity tests were conducted in accordance with the USEPA manual, "Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms" (USEPA, 1991) and USEPA Region 2 SOP 5.1.

<u>Receiving Water Chronic Toxicity Tests</u> The sea urchin, *Arbacia punctulata*, fertilization test is one of six short-term toxicity tests for estimating the chronic toxicity of aqueous samples published in the EPA toxicity manual, *Short-term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Water to Marine and Estuarine Organisms,* 600/4-91/003. The method consists of exposing dilute sperm suspensions to receiving water samples for one hour. Eggs are then added to the sperm suspensions. Two hours later the test is ended by the addition of a preservative. Percent fertilization is determined by microscopic examination of a subsample from each treatment. The test endpoint is reported statistically significant reduction or increase in fertilization percentage (first cleave) in receiving water sample as compared to a control or reference sample. The receiving water and effluent dilution series used for acute testing of *M. bahia* and *M. beryllina* were also tested using .

All receiving water samples were undiluted and replicated five times. A two way analysis of variance followed by an appropriate multi comparison test were conducted to determine if significantly different survival between the VIRIL receiving water samples and the reference stations or laboratory control occurred. All statistical tests were performed at an alpha of 0.05.

3.5.1.9 <u>Plume-focused Sea Grass Survey</u>

Submerged aquatic vegetation (SAV), which includes sea grasses, provides essential nursery habitats for a wide variety of economically important fish and shellfish. The grasses and attached epiphytes provide a vital food source for these commercially and ecologically important species. The sea grass beds provide shelter for juvenile fish development.

In addition to fisheries habitat, sea grass beds provide a vital food source for the endangered species. Federally listed endangered species, such as the green sea turtle, forage on the shoots of the turtle grass which cover much of the shallows within the influence of the VIRIL discharge. Sea grasses also help to stabilize sediments typical of shallow estuaries or bays and protect against erosion of coastal shorelines by diminishing wave energy.

Among the most severely impacted sea grass communities in the northern Gulf of Mexico and those of primary concern include: turtle grass (*Thalassia testudinum*) and shoal grass (*Halodule wrightii*). These are slow growing species that indicate climax conditions of a healthy sea grass bed in oligotrophic conditions such as typically found in clear tropical Caribbean waters. These species are abundant along the southern coast of St. Croix.

Known causes of acute SAV habitat degradation include activities that increase water turbidity and consequently decrease light available for plant photosynthesis. Observed plume characteristics, which include severe color and turbidity aspects, could potentially impact light penetration to a significant degree. Another potential cause for SAV habitat loss in this area is increased nutrient loading leading to production of fast growing algal species which can out-compete the vascular, monocot sea grasses.

A randomized observation of the grasses, within the biased sampling grid, was performed to determine whether conditions of the plume are affecting normal growth. The main objective of this study was to quantify critical biomass distributions of sea grasses for comparison between those in potential target areas and those in an unaffected reference area.

Diving operations from the ANDERSON rigid-hulled inflatable boat (RHIB) were employed to collect these samples. Five target stations in the prevailing plume profile were surveyed. Two reference stations, located up current of the outfall in areas outside the prevailing plume, were also surveyed. At each station, nine samples were collected, three replicates within each of three randomly placed observation units in the vicinity of each target and reference station. Observation units of 1 m^2 were established using a square grid quadrat framing device placed at the designated sample location. The quadrat was subdivided into 25 (five by five) internal grid sectors. Three random positions within the quadrat were identified prior to the operation using a random number generator. This process was repeated twice more near each designated location, as described below. Appendix Figure A-4 presents locations of SAV observations.

The randomly positioned triplicate samples were collected at each station as follows. The quadrat was dropped through the water column at the station location, so as to prevent biased selection of a specific grass area. First, a 3-inch ring was placed by a diver within the randomly identified quadrat sector for collection of the grass blade sample. A sample of all the sea grass blades within the ring was collected by using stainless steel scissors to cut the blades at the sediment level. The grass blade sample was placed into a zipper-sealed bag immediately upon collection. Next, samples of the sea grass roots within the quadrat sector were collected using a 10-inch by 3-inch inside diameter PVC pipe coring device. The 3-inch ring was removed, the corer was placed within the quadrat sector and advanced into the sediment. The corer was advanced into the sediment to a depth of 8 to 10 inches, which is sufficient to collect the entire length of the root/rhizome. The corer was slightly rotated and removed from the bottom carrying the grass root, and any sediment remaining compacted in the corer. The sediment containing the grass was removed and placed into a zipper-sealed bag immediately upon collection. The same procedure was used for each of the triplicate samples within the quadrat. The two subsequent quadrat samples at that station were collected by spinning a carabiner to determine a random direction, swimming five fin kicks in that direction, then placing the quadrat and repeating the process. Where no sea grass was encountered at a given spot, another spot was selected using the carabiner method described above.

Sea grass samples were analyzed to determine biomass on the basis of moisture-free total solids. Separate blade and root biomass was determined for each sample. Analytical methods for the biomass determination included an acid-clearing procedure to eliminate measuring mass attributed to calcification in those plant species where appropriate.

To augment the biomass observation sediment samples were collected in areas associated with the sea grasses and analyzed for grain size. The sediment sample for grain size analysis was collected at each quadrat placement by advancing an 8-inch-long, 1-inch diameter acrylic sampling tube into the bottom left corner of the quadrat. The sample tube was capped and placed into a zipper-sealed bag for shipping.

3.5.2 Coral Reef-focused Survey and Nonterrigenous Sediment Sample Collection

The discharge plume from VIRIL has been observed along the entire southern coastal shelf west of the outfall. These observations, made during the November 2000 survey, include general shading by the discolored water, and presence of a nonterrigenous light fluffy material covering some hard corals and benthic pavement. Sampling and observation stations in the far field were not focused directly in the observed plume, rather they were established based on probable locations of the key biological target, schleractinid or stony corals. The coral disease observation locations were designed in a randomized scheme of locations throughout areas of coral benthic environment as identified in the NOAA benthic characterization maps. The sampling locations for the nonterrigenous fluff material were placed biased to approximate locations that were observed in the November 2000 survey.

3.5.2.1 Coral Disease Observation

The objective of this study was to quantify coral species and diseases for comparison between potential target areas and unaffected reference areas. Observation stations were chosen by placing a random grid pattern over a hexagonal overlay within zones that are indicated to contain coral benthic hard bottoms. Three sampling sites were to be characterized in each of the five coral zones.

Surveys were designed to be conducted by divers using a radial arc transect method to observe coral conditions in a standardized way at each station. The radial transect is basically a 2-m wide circular path traversing 360 degrees at a 10-meter radius around the station location origin point. The general method involved using a 6-ft long rod as an anchor point at the origin. While the base of the rod is anchored in the bottom, a 10-m line at the top of the rod was to be stretched to its length by an assist diver. As the line is rotated 360 degrees around the origin, the surveying divers would enumerate all live and diseased corals within the radial path bounded by the 8-m and 10-m tracings in the radius line. The two surveyors were to swim in concentric circles directly over the line, one recording the number of colonies of each coral species and the other recording the number of colonies of each species that displayed signs of a specific disease. The surveyors were to count colonies larger than 10 cm that fall directly below each 2-m segment of the line, providing more than half of their area occurred within the segment. Replicate arcs were to be made at multiple locations to ensure accuracy.

The data collected at each station was to include: total number of colonies of each species (colonies larger than 10 cm) and total number of colonies of a specific coral species affected with the coral diseases. Observation grids were set up in each target and reference location. Observations recorded from replicate grids for each target area were designed to be compared to observations recorded from replicate grids of the reference area.

3.5.2.2 <u>Nonterrigenous Sediment Particulate Morphology Analysis</u>

Sediments, corals, and benthic pavement, in the far field, were observed during the 2000 survey to be covered with a mat of fluffy light colored material that was of a similar consistency to the dark solids observed in the immediate vicinity of the plume, and did not appear to be of a terrigenous nature. Samples of the far field mat, as well as the highly turbid sea water in the immediate vicinity solids plume and seawater in intermediate locations, were collected using various sampling devices. Water samples in the immediate vicinity and near field were collected in water samples using the 4.4-L Alpha bottle deployed from the DPNR boat. Samples of fluffy mat material in the far field were collected by divers using a 1-L suction collection cylinder, specifically devised to collect this substance.

The samples were shipped to EPA's National Enforcement Investigations Center laboratory in Denver for morphological analysis of the particles to see if a correlation could be made between sediments in the far field and those in the effluent and immediate vicinity samples. Morphological characterizations were made using light and scanning electron microscopy. The electron microscope was also used to perform elemental analysis of particles. Specific methods for analyses were not established due to the unknown nature of the material. The planned method was to observe and attempt to identify physical, morphological, or chemical indicators that could be correlated between the source and far field materials.

3.6 Results

3.6.1 Water Quality Monitoring

3.6.1.1 Hydrographic Profile

The following water quality parameters were measured: temperature, dissolved oxygen (DO), pH, and salinity. A complete presentation of the water quality profiling data is presented in Appendix Table A-4.

Temperature measurements within the plume monitoring stations ranged from 25.77° to 26.7° Celsius (C). Temperature measurements in the up current reference monitoring stations ranged from 25.88° to 26.39° C. The temperature measurements within the plume exhibited a range and distribution that is expected in this coastal ocean environment. There were no individual measurements or trends that indicated any thermal influence from the VIRIL discharge.

PH measurements within the plume monitoring stations ranged from 7.51 to 8.02. PH measurements in the up current reference monitoring stations ranged from 8.07 to 8.15. The plume pH measurements exhibit a range and distribution that are expected in this coastal ocean environment. There were no individual measurements or trends that indicated any pH influence from the VIRIL discharge.

DO measurement within the plume monitoring stations ranged from 5.17 to 6.84 parts per million (ppm). DO measurements in the up current reference monitoring stations ranged from 5.66 to 6.33 ppm. Of the 365 DO measurements recorded throughout the plume and reference areas, 15 measurements within the plume area were observed to be nominally less than the water quality criterion of 5.5 ppm. The lowest DO measurement, 5.17 ppm, was recorded at the bottom location in station V1C. This is the centerline station located nearest to the discharge outfall within a distance of about 5 to 15 meters from the end of pipe. Although this excursion of the DO WQC is within the bottom-dwelling heavy particulate portion of the discharge plume and may indicate some influence from the oxygen demanding property of the discharge, it does not represent a biologically significant depletion of oxygen and is very localized to the direct discharge area.

The other 14 DO excursions were measured at three locations in the far field. The minimum distance from the outfall at which five of these nominal excursions were measured was 1.3 nautical miles (nm). At location F1C all five depth DO measurements ranged from 5.45 to 5.48 ppm. The rest of the DO excursions were measured on transect F3 at a distance of about 2.6 nm. Those DO measurements ranged from 5.41 to 5.49 ppm. The WQC specifically requires DO measurements to be not less that 5.5 ppm for any reason other than natural conditions. The 14 DO measurements recorded above should not be considered to be unqualified excursions from the water quality criterion, because given the variability in instrument sensitivity, calibration, and operation, the nominal degree of difference from the WQC natural fluctuation can not be attributed to the plume, and may reflect natural fluctuation.

The rest of the plume DO measurements exhibited a range and distribution that is expected in this coastal ocean environment. There were no individual measurements or trends that indicated any oxygen depletion influence from the VIRIL discharge.

Salinity measurements within the plume monitoring stations ranged from 35.97 to 36.37 parts per thousand (ppt). Salinity measurements in the up current reference monitoring stations ranged from 36.3 to 36.42 ppt. The plume salinity measurements exhibited a range and distribution that is expected in this coastal ocean environment. There were no individual measurements or trends that indicated any salinity influence from the VIRIL discharge.

3.6.1.2 Five-day Biochemical Oxygen Demand

Table 1 presents BOD and COD results, as well as those for total organic carbon (TOC). Since high levels of organic materials in the wastewater are believed to contribute to its high BOD, analyses for TOC were performed to provide supplementary information for the BOD and COD analyses. As shown in the BOD column of Table 1, the receiving water can be characterized to exhibit three basic ranges of BOD concentrations:

- 10 mg/L and greater in the immediate vicinity;
- 4 to 7 mg/L BOD throughout the rest of the observed plume; and
- undetected BOD in the reference area.

Table 1 Summary of Oxygen Demand Analyses

	BOD (mg/L)	COD (mg/L)	TOC (mg/L)
Immediate Vicinity			
V1C	10.0	ND* (200)	ND (1.0)
V2CR	30.0	350	47.0
V3C**	27.0	390	61.0
Near Field			
N1C	4.3	ND (200)	1.1
N3C	6.9	690	3.6
N5C	4.3	ND (200)	ND (1.0)
Far Field			
F1C	3.4	280	ND (1.0)
F3C	3.8	430	ND (1.0)
F5C	4.8	280	ND (1.0)
Reference			
RA1C	ND (2.0)	ND (200)	ND (1.0)
RA2C	ND (2.0)	ND (200)	ND (1.0)

* - ND = not detected at the concentration in parenthesis
** - V3C is a QA duplicate sample of V2CR

The BOD results from near and far field samples show fairly consistent low levels. The immediate discharge vicinity shows BOD levels that may be 3 to 5 times the near and far field levels. When compared to undetected BOD in the two reference areas, these results indicate that BOD properties of the discharge persist in the receiving water within the influence of the discharge from VIRIL.

3.6.1.3 Chemical Oxygen Demand

As shown in the COD column of Table 1, there is no observed trend in the COD detected throughout the observed plume. COD was detected at fairly consistent levels slightly above the detection level in several stations throughout the observed plume. COD was not detected in the two reference areas. COD was not detected at three of the nine stations sampled within the observed plume, which could be a result of analytical variability or variability in the local orientation of the plume at time of the sample collection. Although there were three stations where COD was not detected, when comparing the detected COD within the observed plume to undetected COD in the two reference areas, the results indicate that COD properties of the discharge persist in the receiving water within the influence of the discharge from VIRIL.

3.6.1.4 Total Organic Carbon Analysis

As shown in the TOC column of Table 1, there was notable detection of total organic carbon (TOC) in the immediate vicinity. TOC concentrations in samples V2CR and its duplicate V3C exhibited concentrations an order of magnitude above the detection limit. TOC was not detected in sample number V1C. This erratic result can be attributed to variability in the local orientation of the plume at the time of the sample collection, and the failure of the sampling apparatus to fall within the solids plume nearest the outfall where it presents its lowest profile and its narrowest width. TOC concentrations in the two nearest near field samples exhibited levels slightly above detection. TOC concentrations in the rest of the near field, far field, and reference areas were not detected. When comparing the detected TOC concentrations in the immediate vicinity and near field, the results appear to show a trend that is consistent with, and a direct influence of, the solids plume from the VIRIL discharge.

3.6.1.5 Eutrophication Nutrient Analysis

Table 2 presents results of nutrient (nitrate, phosphorous, and ammonia) analyses. Nitrates were not detected in any sample. Phosphorous and ammonia each exhibited a spike in the immediate vicinity sample station. Concentrations were detected at fairly consistent levels slightly above detection limits throughout the near field, far field and reference areas. When comparing detected phosphorus and ammonia within the observed plume to that in the two reference areas, these results seem to indicate some minor influence from the VIRIL discharge in its immediate vicinity, but no specific influence from the discharge in the near field and far field.

Table 2 Summary of Organic Carbon and Eutrophying Water Quality Analyses			
	Nitrate (mg/L)	**Phosphorus (mg/L)**	**Ammonia (mg/L)**
Immediate Vicinity			
V1C	ND* (.05)	ND (.05)	0.7
V2CR	ND (.05)	0.18	0.11
V3C**	ND (.05)	0.18	0.1
Near Field			
N1C	ND (.05)	0.07	0.07
N3C	ND (.05)	0.07	0.07
N5C	ND (.05)	0.08	0.06
Far Field			
F1C	ND (.05)	0.07	0.06
F3C	ND (.05)	0.07	0.07
F5C	ND (.05)	0.07	0.06
Reference			
RA1C	ND (.05)	0.07	0.06
RA2C	ND (.05)	0.07	0.06
* - ND = not detected at the concentration in parenthesis ** - V3C is a QA duplicate sample of V2CR			

3.6.1.6 Nonterrigenous Sediment Particulate Morphology Analysis

During the sampling event, samples were collected at the facility and in the immediate vicinity as planned. Samples in the far field were collected at the specified locations. These locations did not exhibit a strong presence of the fluffy material as observed in the November 2000 survey. Therefore, far field samples amounted to collection of water and particles from the coral and pavement surfaces where a thin coating of white particulate matter was observed. The findings of the fingerprint analyses are given in a narrative rather than quantitative description. Table 3 presents the narrative descriptions.

All testing techniques showed basically the same things: sand, pieces of shell, and single- and multi-cell algae. The observations were consistent with the presence of marine sediment. Because no sample of the target fluffy sediment was available, a fingerprinting test could not be developed. Testing did not indicate any obvious particle types that are useful for tracing effluent from the discharge to the receptor areas. (EPA NEIC, 2002)

Table 3 Results of Microscopic Examinations Rum Distiller CWA Fingerprinting St. Croix, Virgin Islands		
Sample Location and Assigned Tag Number	**Light Microscopy Findings**	**SEM/EDS Findings were consistent with:**
PR-1, NE03946	Single-celled algae, single-celled algae clumped together, diatoms, sponge spicules, radiolaria, shells and sand	Abundant calcium carbonate sediment grains, infrequent particles of quartz, infrequent particles of feldspar, infrequent particles of organic material
PR-1A, NE03948	Single-celled and multi-celled algae	Abundant calcium carbonate sediment grains, infrequent particles of quartz, infrequent particles of organic material, infrequent particles of brass
PR-2, NE03943	Single-celled algae, single-celled algae clumped together, diatoms, multi-celled algae	Abundant calcium carbonate sediment grains, infrequent particles of quartz, infrequent particles of feldspar, infrequent particles of organic material, infrequent particles of brass
EF-2, NE03944	Single-celled algae, single-celled algae clumped together, algae strands	Infrequent particles of quartz
V1C, NE03940	Single-celled algae, single-celled algae clumped together, algae strands	Infrequent particles of quartz
V2CR, NE03938	Single-celled algae, single-celled algae clumped together, algae strands	Infrequent particles of organic material
NC5, NE03936	Single-celled algae, single-celled algae clumped together, algae strands	Infrequent particles of organic material
IPMS1-5, NE03942	Single-celled algae, single-celled algae clumped together, algae strands	Infrequent particles of quartz, infrequent particles of organic material

3.6.2 Bioassay Monitoring

This monitoring survey employed use of two types of bioassay: whole effluent toxicity tests; and receiving water toxicity tests. The whole effluent toxicity test is a standard regulatory indicator used to gauge the biological suitability of an effluent to be discharged. By exposing surrogate species to various concentrations of the effluent in the laboratory, the test identifies a median tolerance level, or a concentration of the effluent that affects (either through lethality or some measurable impairment) 50 percent of the organisms exposed. This general toxicity indicator is typically used to gauge an effluent, in conjunction with mixing in the receiving water, to support or deny the permitting of an effluent. The receiving water toxicity test was used to measure direct effects from the effluent to the receiving water. By exposing surrogate species to the undiluted receiving water sample (collected within the plume) simultaneous with exposing them to water from an unaffected reference area, the test can be used to detect whether there is significant lethality observed in the receiving water compared to the reference water.

3.6.2.1 Whole Effluent Acute and Chronic Toxicity Tests

The whole effluent toxicity tests were conducted to establish effluent quality at the time of the discharge. Effluent quality can be compared to past and ongoing quarterly effluent monitoring to judge the severity of the given discharge with regard to toxicity. Acute toxicity testing identifies median lethal concentration (LC50) for the fish *Menidia beryllina*, and crustacean *Mysidopsis bahia* exposed to the whole effluent; chronic toxicity testing identifies a 50 percent fertilization inhibition concentration (IC50) for the sea urchin *Arbacia punctulata* gametes exposed to the whole effluent. The organisms were exposed to a series of dilutions of the effluent and sea water. Effluent samples were collected at the same time that receiving water samples for toxicity testing were collected. Effluent sampling the was synchronized with sampling of the receiving water to allow for a general toxicity characterization of the effluent contributing to the plume being monitored in the receiving water. The results of the tests are presented in Table 4.

Table 4. Summary of Effluent Acute and Chronic Toxicity Testing

Organism	LC50 (percent effluent)	IC50 (percent effluent)
M. beryllina	2.3	-
M. bahia	1.5	-
A. punctulata	-	5.2

Toxicity has been consistently measured, during quarterly whole effluent toxicity bioassay testing, below 3 percent wastewater using the marine crustacean, *Mysidopsis bahia* and/or the silversides minnow, *Menidia* sp.(EPA, Feb 2002) The results presented above indicate that the effluent toxicity, at the time of the monitoring survey, was comparable typical effluent toxicity measured during routine monitoring.

3.6.2.2 Receiving Water Acute and Chronic Toxicity Tests

The acute and chronic toxicity tests measured toxic response of the undiluted receiving water collected at each of eight receiving water locations throughout the area of the observed plume. Acute toxicity was measured as lethality in test species, *M. bahia* and *M. beryllina*, exposed to samples of the receiving water. Chronic toxicity was measured as the inhibition of fertilization of the eggs of *A. punctulata* when gametes were exposed to samples of the receiving water. After exposure to the water samples, fertilization was observed as the egg achieving first cleave. Significant inhibition of fertilization was determined by statistically comparing numbers of fertilized eggs in test samples from the plume to numbers of fertilized eggs in samples from the reference area. Test exposures were performed in five replicates of the receiving water and reference samples. Significant lethality and chronic toxicity was determined by statistically comparing survival or fertilization of test organisms in whole sea water samples from the plume to survival in samples from the reference area. All statistical comparisons were calculated using a 95 percent confidence level as described in section 3.5.1.8. A summary of the results of the tests are presented in Table 5. (EPA, Feb. 2002)

Table 5. Summary of Receiving Water Acute and Chronic Toxicity Testing

Sample/ Station ID	*Mysidopsis bahia* % Survival	Stat. Sig 0.05 versus Reference?		*Menidia beryllina* % Survival	Stat. Sig 0.05 versus Reference?		*Arbacia punctulata* %Fertilized	Stat. Sig 0.05 versus Reference?	
		RA1	RA2		RA1	RA2		RA1	RA2
RA1a	98	-	-	84	-	-	86.6	-	-
RA2a	92	-	-	90	-	-	85.0	-	-
V1	**0**	**YES**	**YES**	**0**	**YES**	**YES**	**0**	**YES**	**YES**
V2	**82**	**YES**	No	80	No	No	**0.4**	**YES**	**YES**
N1	98	No	No	90	No	No	**73.4**	**YES**	**YES**
N3	100	No	No	80	No	No	82.8	No	No
RA1b	100	-	-	92	-	-	87.8	-	-
RA2b	100	-	-	90	-	-	87.4	-	-
N5	98	No	No	84	No	No	**74.2**	**YES**	**YES**
F1	100	No	No	86	No	No	89.2	No	No
F3	98	No	No	80	No	No	87.2	No	No
F5	100	No	No	86	No	No	86.6	No	No

Legend of Sample/Station Prefixes:
RA - Reference Area
V - Immediate Vicinity
N - Near Field
F - Far Field

These results show statistically significant toxic responses in samples collected from stations in the immediate vicinity and near field out as far as Station N5.

3.6.2.3 Light Attenuation

A significant species of sea grass, *Thalassia testudinum* (turtle grass), is known to be present throughout the area influenced by the typical profile of the VIRIL plume. *T. testudinum* is considered to provide critical habitat for many endangered species and both commercially and biologically important species. Many investigations have demonstrated that factors related to light penetration, such as distance through sea water and turbidity, are principal factors in determining light quality and depth limits for growth of many sea grasses, including *T. testudinum* (Vincente, V.P. & J.A. Rivera, 1982; Humm, 1956; Kolehmainen, 1972; Ostenfeld, 1905; Tutin, 1942; Burkeholder and Doheny, 1968; Phillips, 1972, 1974; Margalef, 1962; Backman and Barilotti, 1976; Strawn, 1961; Buesa 1975; Orth, R.J. and Moore, K.A. 1983). These findings, from research into submerged aquatic vegetation (SAV) depth limits posed by attenuation of light in the water column, are useful in characterizing ocean conditions for supporting SAV in waters where light penetration is being impeded by presence of a turbid discharge plume, such as in the VIRIL discharge receiving water.

In this study, ambient light in the receiving water was measured at 1-m depth intervals, and ambient light at the surface was measured simultaneously with each underwater light measurement. The light measurement profiling data are presented in Appendix Table A-2. Calculations were performed, using the multiple depth light measurements and their corresponding surface light measurements, to determine the light attenuation coefficient (K) at each station along each transect of the study area. Appendix Table A-6 presents spreadsheet calculations of the attenuation coefficients. A regression formula for comparing data on attenuation coefficients and observed depth of colonization of *T. testudinum* was developed in a 1991 compilation of sea grass research data from botanical literature (Duarte, 1991). This formula can be used to identify critical depths for colonization of the sea grasses based on available light.

Using this regression formula, a colonization depth (Z_c) was calculated for each station. The colonization depth represents the depth at which SAV growth can be sustained. Depths below the colonization depth are considered to have insufficient light to support normal growth of the sea grasses. The data were plotted to determine estimates of depths at which sufficient light penetration would be available to sustain the submerged aquatic vegetation.

Water depths in the areas profiled for ambient light ranged from 4.5 to 5.4 m. Therefore sea grass beds colonization depths calculated to be less than these depths would indicate that there is insufficient light reaching the bottom to support normal sea grass growth. For this monitoring, Z_c values calculated to be 4 m or less were identified as critical colonization depths. Table 6 presents a summary of the critical colonization depths estimated. A graphical presentation of the colonization depth estimated from these data is presented in Figure 5.

Comparisons were then made from the study area to reference areas located in close proximity, maintaining similar physical characteristics, and without influence of the discharge. By comparison the reference areas showed Z_c to depths twice that of the study area, thereby indicating that the reference waters are significantly better suited to sustain light conditions for sea grass growth. By the same token, comparisons within individual transects found areas of acceptable light penetration on the outer edges of the transects, which were designed to be outside the visible plume; yet, stations in the middle of the transects, which were designed to represent water column conditions within the plume, were found to have marked increases in light attenuation, and is represented by low Z_c values. These comparisons showed that light penetration within the plume in much of the study area did not meet the minimum light requirements of *T. testudinum* (Fourqurean and Zieman,1991; Duarte, 1991; and Phillips, 1960).

Table 6. Summary of Critical Colonization Depths (Z_c)									
Reference Area				**Immediate Vicinity**					
Station	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**		
RA1A	13.90	RA2A	10.99	V1A	11.55	V2A	31.73		
RA1B	14.95	RA2B	10.14	V1B	3.76				
RA1C	20.52	RA2C	14.83	V1C	2.61	V2C	2.16		
RA1D	8.97	RA2D	9.01	V1D	4.37				
RA1E	26.47	RA2E	21.11	V1E	9.57	V2E	10.86		
Near Field									
Station	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**
N1A		N2A	16.30	N3A	23.23	N4A	4.96	N5A	5.61
N1C	6.09	N2C	3.69	N3C	2.45	N4C	2.93	N5C	2.22
N1E	10.16	N2E	5.81	N3E	25.70	N4E	9.27	N5E	7.29
Far Field									
Station	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**	**Station**	**Z_c (m)**
F1A	5.87	F2A	4.85	F3A	5.39	F4A	2.37	F5A	3.48
F1B	3.10	F2B	3.62	F3B	3.56	F4B	4.38	F5B	3.74
F1C	2.65	F2C	3.20	F3C	3.85	F4C	5.58	F5C	4.76
F1D	2.79	F2D	3.63	F3D	4.42	F4D	5.11	F5D	3.77
F1E	8.61	F2E	6.66	F3E	11.49	F4E	11.08	F5E	5.90

A graphical presentation of the colonization depths estimated from the ambient light data is presented in Figure 5.

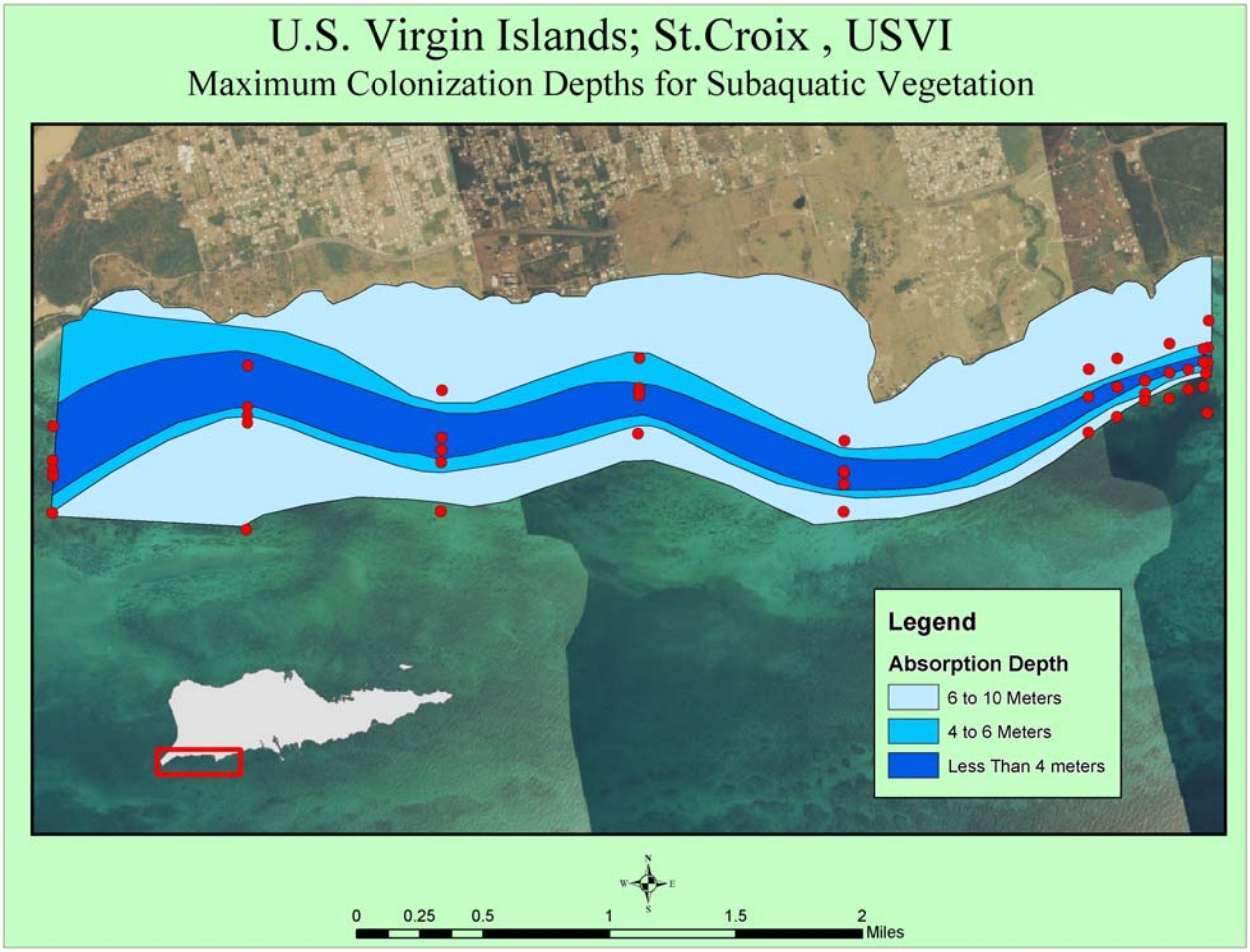

Figure 5. Colonization Depths Calculated from Light Profiling

A simple assessment of the critical light attenuation at any particular depth can also be made by identifying loss of light penetration above 85 percent, which has been shown to be the minimum level of light required for the growth of *T. testudinum* (Duarte). In the survey, light was observed to be attenuated to an average of 90 percent and above in the first three meters from the surface in the plume continuously from station V1 extending out to furthest station F5 within all transects. Bottom measurements of the light attenuation resulting from the plume was measured at levels of 99 percent continuously in the vicinity and near field locations. Light attenuation was measured at an average of 93 percent at the bottom along this range of transects from V1 to F5 which extends approximately 6 miles from the source point. In comparison, light attenuation in a reference area was measured to 51 percent, 62 percent, 63 percent, and 63 percent at 3, 4, 5, and 6 meters respectively. Penetration of light in the nonimpacted areas to such depth indicates a significant potential for impact over a large area of sea floor resulting from the occlusion of light by this discharge.

3.6.2.4 <u>Sea Grass Survey</u>

Sea grass samples were collected for biomass analysis. The study was designed to determine ratios of blade mass to root mass of SAV species at each location. The blade-to-root ratio is a good indicator of impaired growth, as blade mass would be expected to be reduced in light-deprived environments. Data analyses of the samples was designed to determine whether statistically significant reduction in growth could be identified in SAV exposed to the plume. However, the actual SAV samples obtained were not suitable to perform the planned statistical comparisons. The diversity in plant species, and even phyla, that was encountered resulted in samples that could not appropriately be compared for the planned biomass ratio statistical analysis due to differing plant architecture and biomass distribution.

During field operations, visual reconnaissance of the planned sampling locations was conducted to identify those where there was sufficient coverage of SAV to collect representative samples. The reconnaissance observation were conducted using a Seascope subsurface viewer, and Ponar sediment sampling device. The far field recon identified transect F3 as not having any areas of sufficient SAV coverage. Regarding the near field, because of the close spacing of the near field transects, SAV stations in transects N2 and N4 were eliminated, as the minor benefit of such closely resolved sampling was not worth the sampling effort, given the difficult sea conditions and condition of SAV beds encountered in the near field. The dive to collect SAV station N5 resulted in finding only a bed of the alga *Caulerpa prolifera*, and no other species encountered along the entire transect. *C. prolifera* is an algae that has small rhizomes and cannot be considered appropriate for comparison to sea grasses with much heavier rhizomes such as those species collected at the reference locations. Therefore, the sample from that transect was also eliminated.

During dive operations to video document the immediate vicinity and near field, no sea grass coverage was observed at the immediate vicinity and N1 locations. In addition, the sediments were observed to be extremely hard and compacted and resisted penetration of the core sampling device. This hard surface was in great contrasted to the sandy bottom in the area in immediately up current (i.e., prevailing conditions) of the outfall. The sampling culminated in collection of two reference area stations and five plume areas stations. The following stations were eliminated from the sampling design: F3C, N5C, N4C, N2C, and N1C. Table 7 presents results of the biomass and sediment grain size analyses for the samples collected.

Although statistical analyses were not performed, a qualitative evaluation of the sampling data and observed benthic condition can be made to identify an area that appears to be affected by influence from exposure to the discharge. In a general comparison of the data from the plume sample transects to those from the two reference area transects, there is an observable difference in total biomass and dominant species in the area between the outfall and Transect F1. This assessment is supported by the following observations:

the visual observations regarding the absence of SAV in the near field transects;
the observed compacted nature of the near field sediments;
marked drop in total biomass detected in samples N3C and F1C.

Table 7. Summary of Average Sediment Particle Size, and Root and Leaf Dry Weights for Marine Macropyhtes Collected in the Vicinity of the VIRIL Outfall, February 2002.							
Station ID	**Quad**	**Predominant Particle Size**	**Predominant Species**	**Average Leaf Wt. (g) Per Quad.**	**Average Root Wt. (g) Per Quad.**	**Average Leaf Wt. (g) Per Area**	**Average Root Wt (g) Per Area**
RA1C	Q1	Muddy sorted sand	*Thalassia, Halimeda*	.570	1.917		
RA1C	Q2	Muddy sorted sand	*Thalassia, Halimeda*	.468	2.872		
RA1C	Q3	Muddy sorted sand	*Thalassia, Halimeda*	.642	1.591	***.560***	***2.127***
RA2C	Q1	Very coarse sand	*Halimeda*	1.274	1.305		
RA2C	Q2	Very coarse sand	*Halimeda*	1.187	1.550		
RA2C	Q3	Muddy very coarse sand	*Halimeda*	.353	1.661	***.938***	***1.505***
F5C	Q1	Medium-fine sand	*Thalassia*	.736	1.906		
F5C	Q2	Medium sand	*Thalassia*	.200	1.701		
F5C	Q3	Medium-fine sand	*Thalassia*	.164	1.316	***.367***	***1.641***
F4C	Q1	Fine sand	*Thalassia*	.183	2.691		
F4C	Q2	Fine sand	*Halimeda, Thalassia*	.741	.104		
F4C	Q3	Fine-medium sand	*Thalassia, Halimeda*	.382	.274	***.435***	***1.023***
F2C	Q1	Fine-medium sand	*Halimeda*	.303	.966		
F2C	Q2	Fine-medium sand	*Thalassia*	.115	1.333		
F2C	Q3	Fine-medium sand	*Thalassia, Halimeda, Halophila*	.185	1.233	***.201***	***1.177***
F1C	Q1	Coarse sand	*Thalassia, Syringodium*	.064	.348		
F1C	Q2	Sorted sand	*Thalassia, Syringodium*	.146	.678		
F1C	Q3	Fine sand	*Thalassia, Syringodium*	.093	.670	***.101***	***.565***
N3C	Q1	Sorted sand	*Thalassia, Halimeda, Penicillus*	.212	1.152		
N3C	Q2	Sorted sand	*Halimeda, Syringodium, Udotea*	.210	.442		
N3C	Q3	Sorted sand	*Halimeda*	.357	.800	***.260***	***.798***

Legend of Sample/Station Prefixes:
RA - Reference Area
N - Near Field
F - Far Field

3.6.2.5 Coral Disease Observation

Reconnaissance dives were performed in each of three target areas in attempt to establish the three locations in each for the definitive coral survey. Snorkeling survey dives were performed at 26 of the 30 designated target locations. Four locations were rejected because of presence of the plume which, without proper protective equipment, precluded completing a visual reconnaissance. At each of the 26 stations, insufficient coral coverage to perform a coral survey was observed. Therefore, coral disease observations were not performed, and data were not collected, because of a lack of sufficient coral aggregations present in the areas targeted as potentially exposed to prevailing plume conditions. Appendix Table A-6 presents the coral reef reconnaissance observations.

3.7 Discussion

Survey Conditions The coastal setting in which the VIRIL outfall is located typically possesses a long-shore current that travels west, driven by prevailing trade winds. This results in a visible plume orientation that is directly related to the current, and typically extends from the outfall west about 6 miles, to the shelf edge at Sandy Point. Although the seasonal persistence of the typical westward current has not been quantified, it is generally recognized that an east to west plume orientation prevails throughout much of the year.

The February 2002 survey was designed to monitor a unique condition, specifically characteristics of and effects from a meandering plume, within a limited window of time and resources for field operations. Aside from the challenges of variability inherent in sampling/monitoring methodology and analytical technology, obtaining representative data during this survey required coordinating the monitoring of a dynamic plume in conjunction with sampling static benthic targets. Observations and sampling locations pertaining to water quality and light attenuation required a “chasing the plume” approach. Observation and sampling locations pertaining to benthic target assessment were established by estimating the most likely exposed target areas based on historic information of the typical plume profile. The samples obtained during the survey provided an acceptable representation of these complex monitoring goals.

During the period that the survey operations were conducted, general conditions can be summarized as follows.

The weather was clear and bright with a persistent wind blowing east to west.
The plume retained the typical east-to-west profile for the duration of the survey.
The plume displayed substantial local spatial variation; it was observed to reach widths exceeding 1,000 m, and it was observed to meander, split, condense continually.
The surface condition was fairly turbulent with waves reaching heights estimated at 3 to 5 feet.

The plume was visible for the entire reach from its origin to the shelf edge west of Sandy Point, a distance of approximately 6-miles, for the duration of the survey. The fate of the plume beyond the shelf edge is not known.
In general, the plume continued to show its two-phase character (i.e., solids plume and color plume).

These conditions resulted in gathering data that is indicative of times when the plume is in its typical shape and orientation, there is maximum sunlight, and there is strong water column mixing.

During a 6-week period prior to starting survey operations, production at the VIRIL facility was stopped for their annual shutdown and maintenance function. The duration of the shutdown was from December 22, 2001 to about January 26, 2002. Production was then briefly started and again shutdown due to mechanical issues. After full startup, effluent discharge began on or about February 1, 2002. On February 5, the VIRIL discharge plume was observed to traverse the entire approximately 6-mile distance from the outfall west to the shelf edge near Sandy Point. The plume was observed to exhibit its typical dark and wide profile. The 6-week shutdown could have affected certain benthic observations (e.g., sea grass impact and nonterrigenous sedimentation) by predisposing them to underestimating effects, because of the absence of exposure. The shutdown would not be expected to affect water column monitoring.

Water Quality Water quality physical characteristics, monitored at 1-m depth intervals throughout the plume, did not identify significant impairment. The temperature, pH, and salinity measurements within the plume exhibited a range and distribution that is expected in this coastal ocean environment. There were no individual measurements or trends that indicated particular influence from the VIRIL discharge.

Similarly, DO measurements within the plume generally exhibited a range and distribution that is expected in this coastal ocean environment. There was one measurement, from within the bottom-dwelling heavy particulate portion of the discharge plume nearest the discharge outfall, that was below the water quality criterion. This excursion of the DO WQC may indicate some influence from the oxygen demanding property of the VIRIL discharge; however, it does not represent a biologically significant depletion of oxygen and is very localized to the direct discharge area.

Although this monitoring does not indicate significant impairment of the water quality, as a single event it was greatly influenced by particular oceanic conditions at the time of monitoring. A strong surface surge and consistent prevailing westerly long-shore current existed during the survey. This condition would account for active mixing of the sea water in this shallow zone, which would tend to mitigate any oxygen depleting influences from the outfall. This high-mixing condition would not represent the most severe conditions for water quality influences, particularly DO, from the plume. Although DO was not detected to be an issue during this monitoring, in the November 2000 monitoring, conditions were quite different. The westerly long-shore current was absent and the surface condition was calm. Under those poor mixing condition, DO WQC excursions were much more numerous, with some areas of biologically significant DO depletion.

Biochemical Oxygen Demand BOD and TOC analyses were performed for samples collected from bottom locations. BOD measurements in the immediate vicinity showed increased levels compared to the reference, near field, and far field locations. Similarly, TOC measurements in the immediate vicinity showed increased levels compared to the reference, near field, and far field locations. The highest BOD and TOC levels (30 mg/L and 61 mg/L respectively) were measured at a distance of about 100 feet from the outfall. Figure 6 presents an illustration of the extent of BOD and TOC influence from the discharge. BOD and TOC are shown to persist to a minimal extent in the receiving water beyond the outfall during conditions of strong mixing. There is a potential for the oxygen demanding character of the effluent to persist beyond this point, and under lesser mixing conditions, it could persist over a greater distance and area. Such persistence of oxygen demanding properties in the water column could impact normal propagation of benthic infauna, colonization of corals, and normal productivity of SAV within the area of exposure.

COD measurement were at or near the detection limit, thus did not display any particular indication of water column influence from the discharge. Phosphorus and ammonia analyses showed nominally increased concentrations in the immediate vicinity of discharge relative to reference, near field, and far field location; nitrate was not detected in any location.

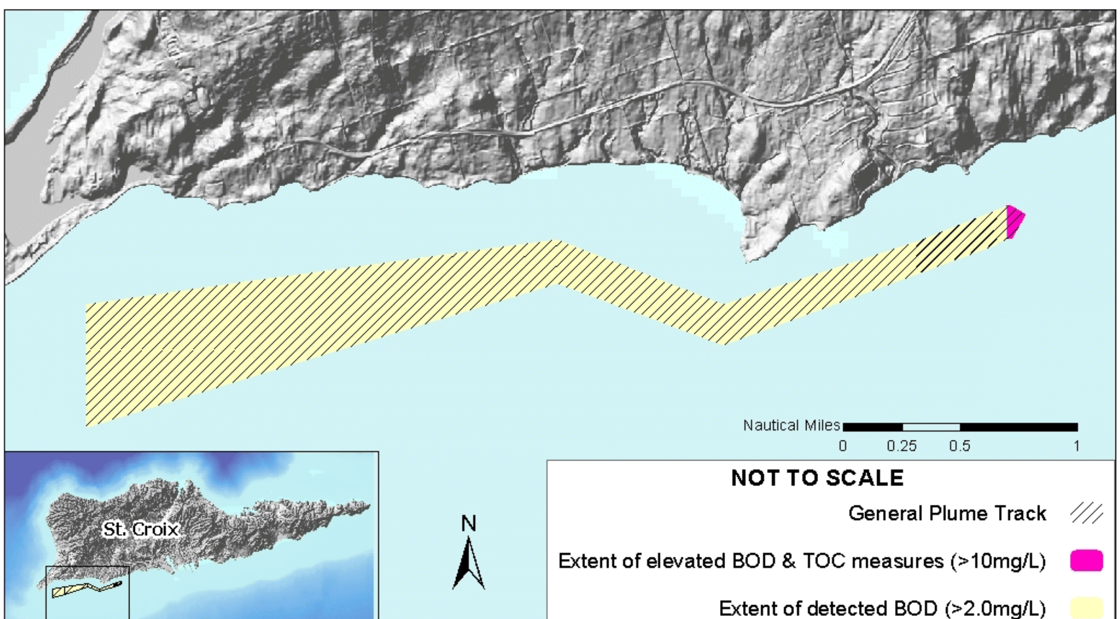

Figure 6: Water Quality Measurement

Toxicity Toxicity tests were performed on the receiving water to evaluate the influence of the discharge directly in the receiving water. In addition, whole effluent toxicity tests performed on effluent samples collected simultaneously with collection of the receiving water samples. The whole effluent tests yielded results that were comparable to the quarterly regulatory whole effluent testing results. This indicates that relative to toxicity, the quality of the effluent at the time of the survey is comparable with typical effluents tested during quarterly monitoring. Therefore, the toxicity characteristic of the receiving water samples collected for the plume testing could be considered to be representative of its prevailing plume toxicity condition.

The toxicity of the receiving water was evaluated by comparing acute and chronic responses from receiving water exposures to reference water exposures. The three stations nearest the outfall, and the furthest near field station, exhibited significant toxic responses in the test organisms. Station V1 showed significant and severe responses in both acute tests and the chronic test, with no survival or fertilization in any of the exposures. Station V2 showed statistically significant responses in one acute test and the chronic test. Thus, acute and chronic toxicity were determined in the receiving water out to a distance of about 100 feet from the outfall. The next contiguous location Station N1, along with Station N5, showed statistically significant toxicity in the chronic test. Although one station between those stations, N3, did not show a significant toxic response, this could be attributed to sampling variability in a highly varying plume profile.

Figure 7 presents an illustration of the extent of receiving water toxicity within which the testing showed statistically significant toxicity. These results indicate an influence from the discharge in the receiving water, and a potential for aquatic toxic impacts at a considerable distance, more than 400 m, from the outfall. This testing does not infer any specific ecological or food chain impacts, it only demonstrates a potential for toxic influence of the discharge in the receiving water under the specific conditions in which the samples were collected. Since the results of the whole effluent toxicity testing were similar to past quarterly monitoring, it is concluded that the receiving water bioassay results are representative of the typical discharge.

Light Attenuation Ambient light measurements identified a substantial area, throughout the entire extent of the observed plume, where light is reduced to a level that would be expected to impair growth of subaquatic vegetation (SAV). Critical colonization depths for turtle grass, *T. testudinum*, were calculated from the results of the light attenuation. Water depths of SAV beds in the coastal area exposed to the VIRIL discharge plume range from 4.5 to 5.4 m. Estimated colonization depths less than 4 m were identified throughout the entire plume, which indicates that the depth limit to support proper SAV growth in such lighting conditions is much shallower than the actual depth of the sea grass beds. Under such lighting conditions, there would be insufficient light to support turtle grass at existing depths, as long as that condition prevailed.

The survey conditions were well suited for measuring maximal light occlusion caused by the plume. The area of plume coverage was at an extreme condition as it extended the entire approximately 6-mile distance from the outfall to the shelf edge west of Sandy Point. The width of the plume was visually observed to exceed 1,000 meters. Measurements of light attenuation

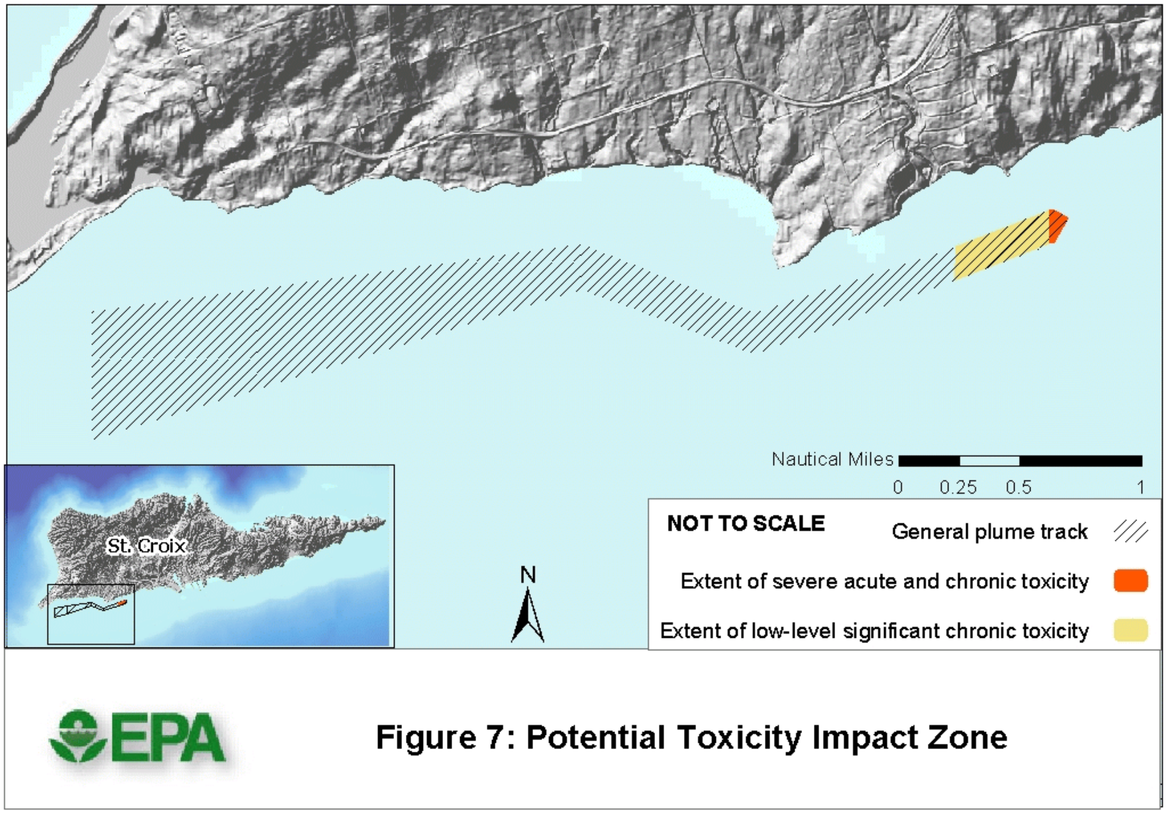

Figure 7: Potential Toxicity Impact Zone

identified a very broad swath of area where light would be insufficient to support normal growth of the SAV.

Estimation of total acreage of biologically significant light attenuation would depend on duration of the exposure of the SAV to the plume as it meanders across the bottom. Such an estimate cannot be calculated in a single snap-shot monitoring. Although a total acreage of area of significant light attenuation was not quantified, it can be surmised that the swath of the plume observed during the survey represents a potential for substantial reduction of SAV due to light attenuation. Figure 8 presents an illustration of the zone of potential critical light attenuation.

<u>Submerged Aquatic Vegetation</u> Impact of this discharge on the SAV is evident by a reduced plant biomass in some areas sampled, absence of SAV in other areas, and benthic sediments in areas absent of SAV that are compacted and likely to be resistant to germination of SAV pioneer species. Figure 9 presents an illustration of the zone of potential SAV impact. The area illustrated to be the extent of observed SAV impact is based on the apparent reduced overall biomass measured in sea grass samples through station F1C. A predominant climax SAV species in this shallow coastal area is the turtle grass, *T. testudinum*. Turtle grass provides vital habitat to support spawning of fisheries, and nursery for green sea turtles, an endangered species.

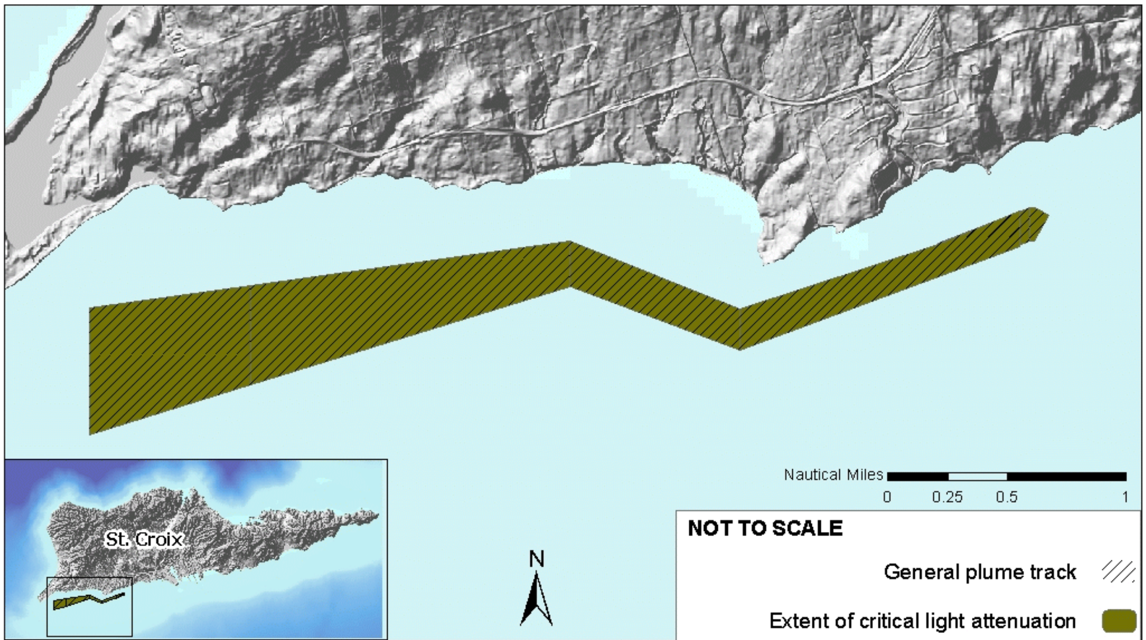

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Figure 8: Potential Light Attenuation Impact Zone

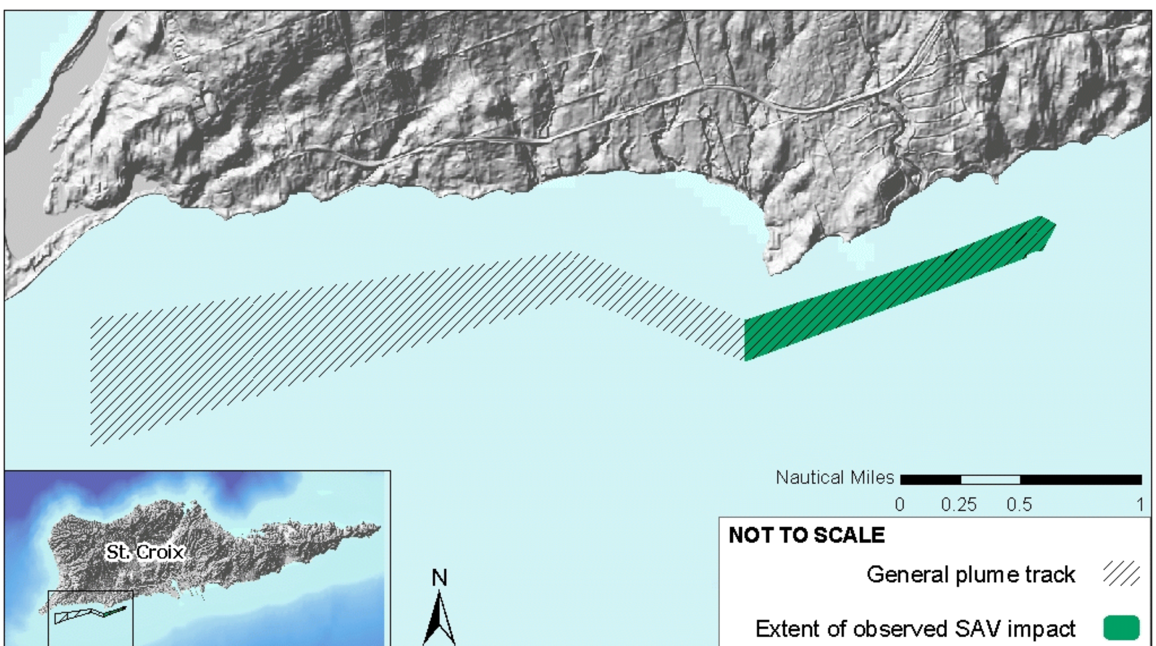

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Figure 9: Potential Subaquatic Vegetation (SAV) Impact Zone

<u>Coral Reefs</u> Impacts to corals could not be determined during this survey. The planned study areas for coral disease observation were located in the shallow shelf, directly west of the outfall, within the more direct exposure to the typical plume profile. Areas designated as “coral on pavement” in the NOAA benthic habitat maps were targeted for disease observation; however, the coral coverage, encountered in the specific locations planned, was insufficient to perform a complete quality-assured coral observation survey. In addition, scattered coral heads suspected to be receiving nonterrigenous sedimentation based on observations from the November 2000 survey, were not observed to be covered with the material during the survey.

Therefore, it is concluded that there are no substantial coral reef aggregations within the direct influence of the typical profile of the plume. Any coral reefs possibly existing at the deeper shelf edge south of the prevailing plume profile, and where the plume disappears at the west shelf edge, could still be exposed to the dispersed water quality influences from the VIRIL discharge plume. Figure 10 presents the planned coral survey locations.

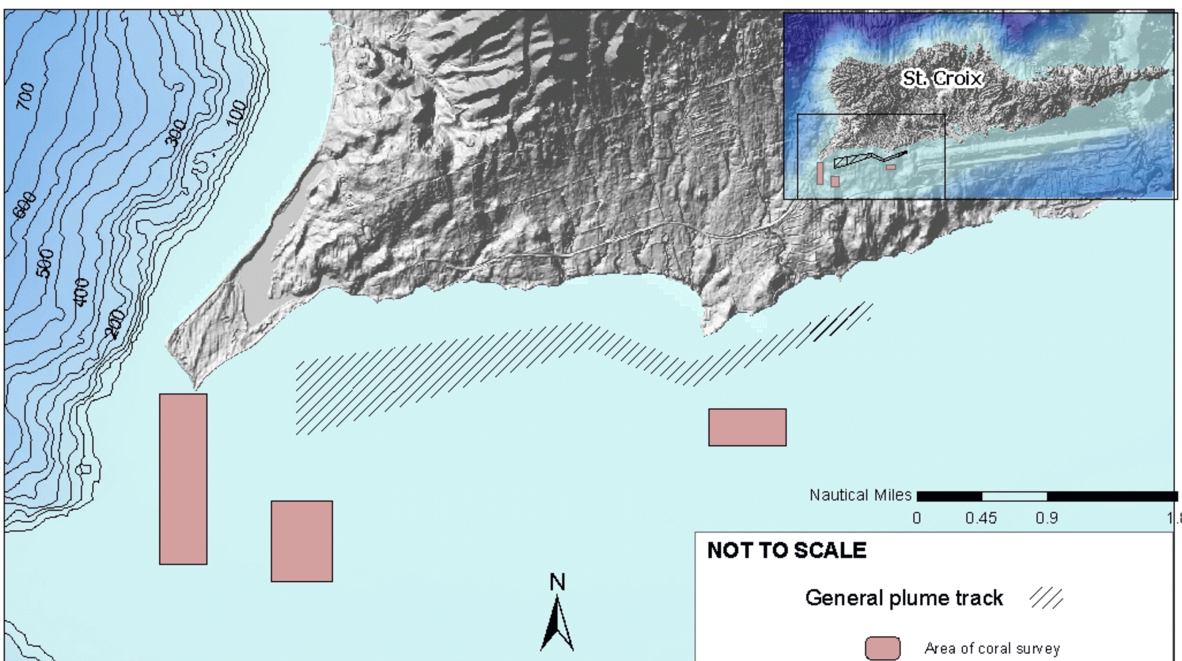

Figure 10: Coral Surveys

3.8 Conclusions

The 2-week effort to collect environmental data in this very dynamic coastal system provided a snapshot characterization of physical, chemical, and biological conditions occurring at that time. The results portray a potential for an assortment of impacts to the coastal environment that lies within the influence of the VIRIL discharge. These results do not represent a condition that can be considered either a worst- or best-case scenario. Some conditions, such as surface turbulence, provided for active mixing of the water column in this shallow area, which would tend to indicate minimal effects of the water quality impairing components of the discharge. Some conditions, such as the steady west-bound spread of the plume, provide for maximum spread of the shading character of the plume, which would indicate high degree of negative effects of the discharge on sea grasses from shading. The area was unaffected by the plume for six weeks prior to the survey because of plant shutdown, thus certain observations of benthic conditions did not represent complete potential for exposure to the plume.

A summary of the significant conclusions follow.

1. A thorough examination of water quality did not identify any significant water quality issues, including depletion of dissolved oxygen. However, although oxygen depletion was not detected in the condition of high mixing present during the survey, there is a potential for the high BOD of the effluent to cause a biologically adverse oxygen content in the receiving water during conditions of low mixing.

2. There is significant acute and chronic toxicity in the receiving water due to discharge of the VIRIL waste.

3. There is a strong turbidity and color attribute of the VIRIL discharge. This presents a potential for a critical adverse light-attenuating condition that could impede normal growth of submerged aquatic vegetation (SAV), such as turtle grass, in a significant area of the receiving water.

4. There appears to be a diminished abundance of SAV within the influence of the plume, which yields a potential to alter critical benthic habitat for endangered species, and both commercially and biologically important species.

5. There are no significant coral reefs identified within direct influence of the VIRIL discharge.

A requirement of the CBERA exemption of VIRIL's discharge from requirements of the CWA is attainment of acceptable environmental conditions. In maintaining the CBERA exemption, "*the Governor of the United States Virgin Islands determines that such a discharge will not interfere with the attainment or maintenance of the water quality which shall assure the protection of public water supplies, and the protection and propagation of a balanced population of shellfish,*

fish, and wildlife, and allow recreational activities, in and on the waters and will not result in the discharge of pollutants in quantities which may reasonably be anticipated to pose an unacceptable risk to human health or the environment because of bioaccumulation, persistency in the environment, acute toxicity, chronic toxicity (including carcinogenicity, mutagenicity, or teratogenicity) or synergistic propensities." The monitoring data and conclusions are presented to assess conditions in the receiving water of the VIRIL discharge in order to support determination on whether the waters are meeting these water quality goals. These data demonstrate impacts and potential impacts to this vital ecosystem that should be considered when evaluating the VIRIL discharge for the CBERA exemption. Based on the information provided above, it can be concluded that the discharge, as monitored in the 2002 survey, threatens the propagation of a balanced population of shellfish, fish, and wildlife, including federally listed endangered species, by its oxygen demanding and light attenuating properties. It has also been shown that the discharge may pose an unacceptable risk to the environment because of the acute and chronic toxicity that was demonstrated in the receiving water.

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Figures

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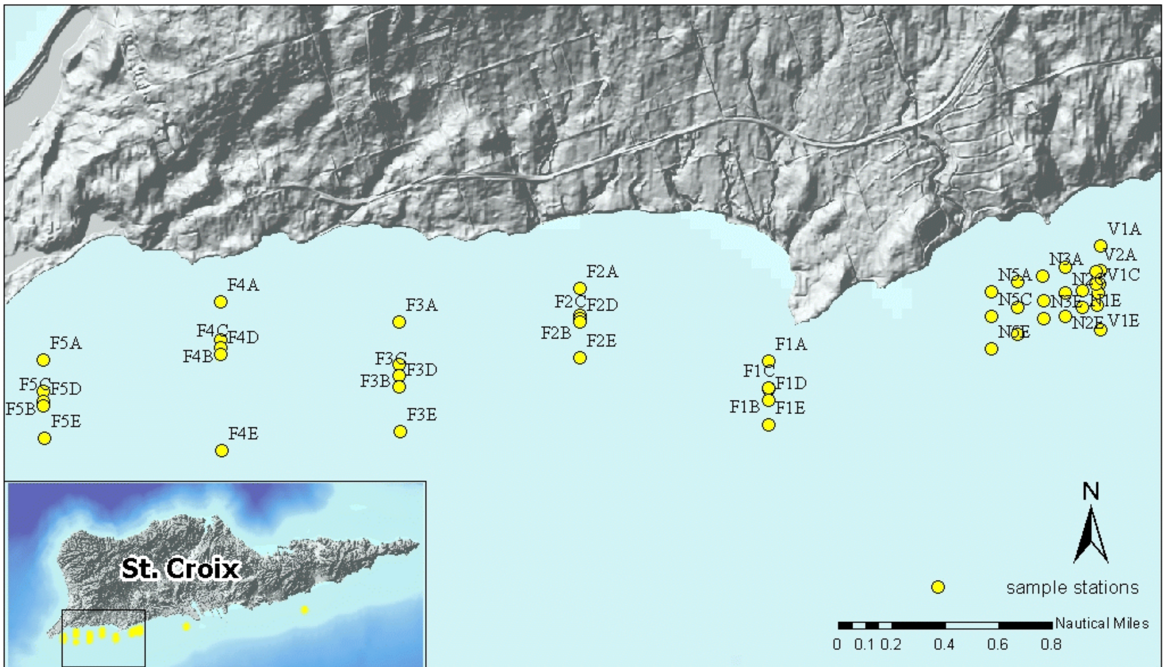

Figure A-1: Locations for Plume-Focused Hydrographic Profiling and Water Quality Samples

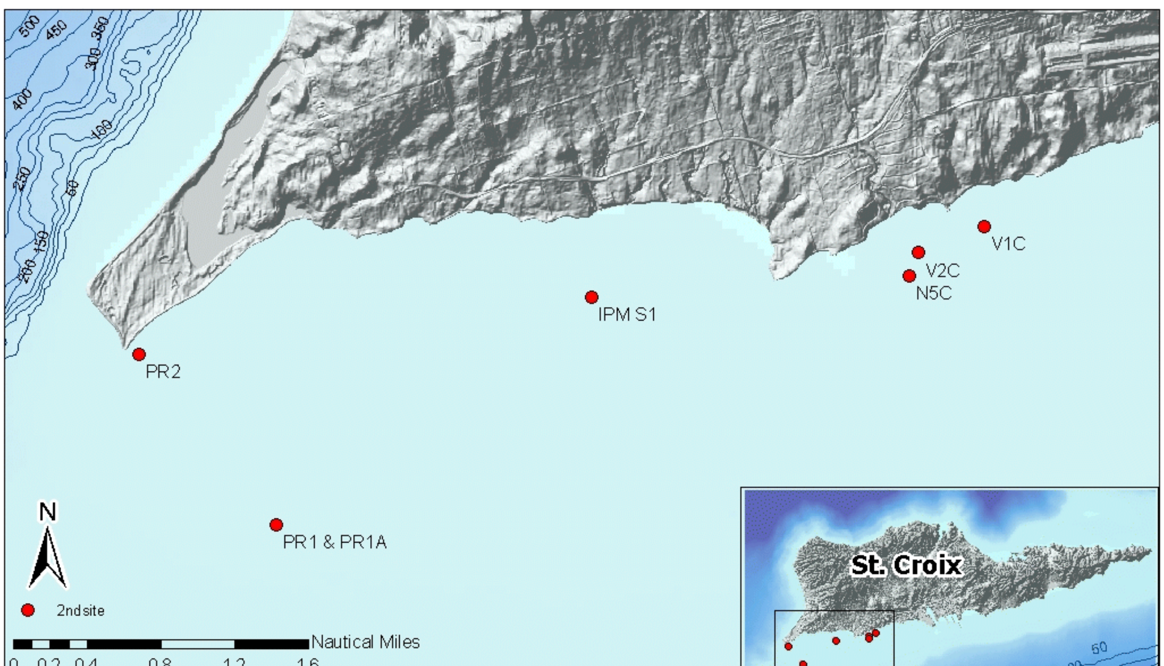

Figure A-2: Sample Locations for Particulate Morphology Analysis

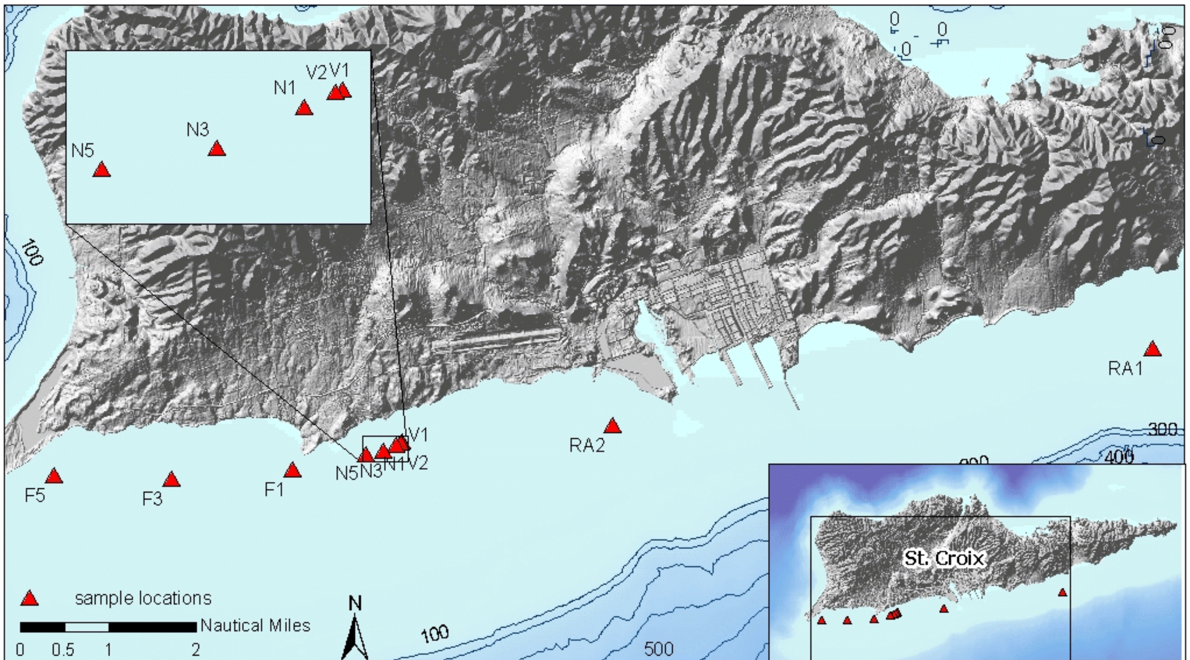

Figure A-3: Sample Locations for Toxicity Bioassay

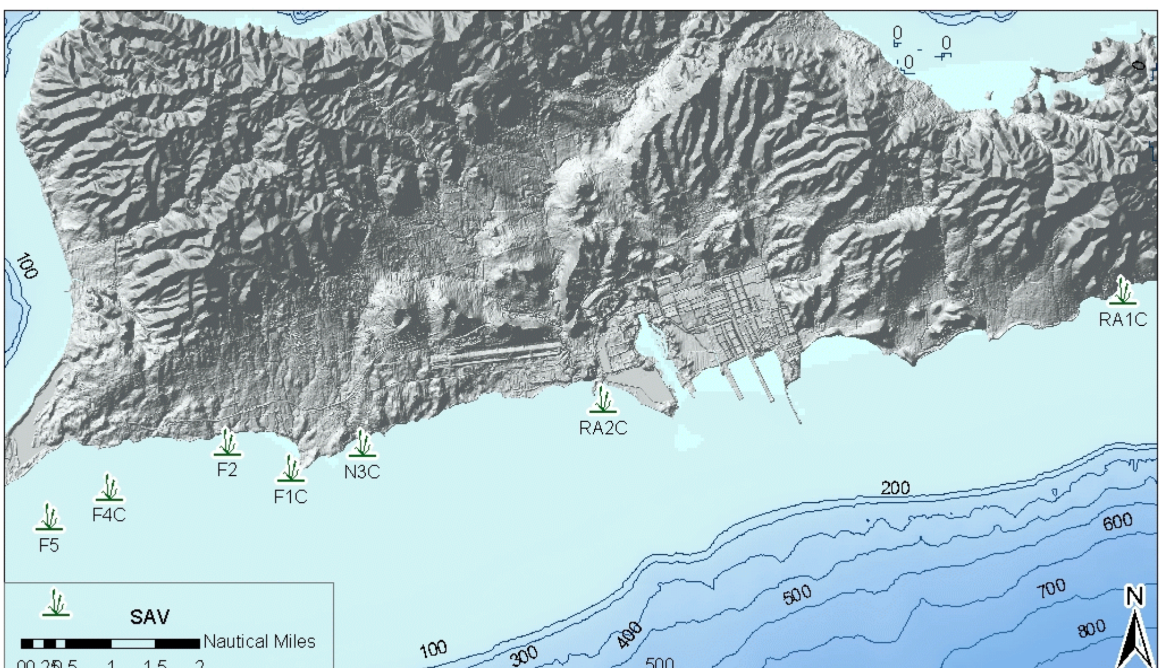

Figure A-4: Locations of Submerged Aquatic Vegetation (SAV) Samples

Appendix A

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Table A-1. Planned Transect Boundary Locations for VIRIL Hydrographic Profiles and Sampling Stations					
TRANSECT		NORTHERN POINT (A)*		SOUTHERN POINT (E)*	
		LATITUDE	LONGITUDE	LATITUDE	LONGITUDE
Immediate Vicinity No. 1	V1	17^0 40.950 N	64^0 49.148 W	17^0 40.918 N	64^0 49.148 W
Immediate Vicinity No. 2	V2	17^0 40.950 N	64^0 49.157 W	17^0 40. 918 N	64^0 49.157 W
Near Field No. 1	N1	17^0 40.944 N	64^0 49.191 W	17^0 40.912 N	64^0 49.191 W
Near Field No. 2	N2	17^0 40.912 N	64^0 49.259 W	17^0 40.880 N	64^0 49.259 W
Near Field No. 3	N3	17^0 40.895 N	64^0 49.346 W	17^0 40.863 N	64^0 49.346 W
Near Field No. 4	N4	17^0 40.863 N	64^0 49.448 W	17^0 40.831 N	64^0 49.448 W
Near Field No. 5	N5	17^0 40.841 N	64^0 49.542 W	17^0 40.809 N	64^0 49.542 W
Far Field No. 1	F1	17^0 40.852 N	64^0 50.449 W	17^0 40.776 N	64^0 50.449W
Far Field No. 2	F2	17^0 40.836 N	64^0 51.185 W	17^0 40.760 N	64^0 51.185 W
Far Field No. 3	F3	17^0 40.574 N	64^0 52.508 W	17^0 40.498 N	64^0 52.508 W
Far Field No. 4	F4	17^0 40.113 N	64^0 53.277 W	17^0 40.037 N	64^0 53.277 W
Far Field No. 5	F5	17^0 39.700 N	64^0 54.184 W	17^0 39.624 N	64^0 54.184 W
Reference Area	RA1	17^0 41.950 N	64^0 40.190 W	17^0 41.918 N	64^0 40.190 W
Reference Area	RA2	17^0 41.135 N	64^0 46.629 W	17^0 41.103 N	64^0 46.629 W

* See Section V. for explanation of designation, northern, and southern points.

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Table A-2. Survey Locations for VIRIL Coral Disease Observations of Far Field and Background Locations				
SAMPLE AREA/ STATION DESIGNATION	SAMPLE NUMBER	HEXAGON SIZE (NM ^{2})	LATITUDE	LONGITUDE
Coral Area 1/CA1	1	0.22	17° 40.42380 N	64° 53.95620 W
Coral Area 1/CA1	2	0.22	17° 40.29060 N	64° 54.15060 W
Coral Area 1/CA1	3	0.22	17° 40.29900 N	64° 54.06300 W
Coral Area 1/CA1	4	0.22	17° 40.13100 N	64° 54.30420 W
Coral Area 1/CA1	5	0.22	17° 39.89820 N	64° 54.14400 W
Coral Area 1/CA1	6	0.22	17° 39.91500 N	64° 54.15900 W
Coral Area 1/CA1	7	0.22	17° 39.58920 N	64° 54.04980 W
Coral Area 1/CA1	8	0.22	17° 39.43440 N	64° 54.13860 W
Coral Area 1/CA1	9	0.22	17° 39.27780 N	64° 53.94840 W
Coral Area 1/CA1	10	0.22	17° 39.23820 N	64° 54.11160 W
Coral Area 2/CA2	1	0.11	17° 39.64800 N	64° 53.49840 W
Coral Area 2/CA2	2	0.11	17° 39.67200 N	64° 53.14860 W
Coral Area 2/CA2	3	0.11	17° 39.60960 N	64° 53.47680 W
Coral Area 2/CA2	4	0.11	17° 39.51360 N	64° 53.18640 W
Coral Area 2/CA2	5	0.11	17° 39.46200 N	64° 53.38440 W
Coral Area 2/CA2	6	0.11	17° 39.41640 N	64° 53.06160 W
Coral Area 2/CA2	7	0.11	17° 39.33420 N	64° 53.16960 W
Coral Area 2/CA2	8	0.11	17° 39.22680 N	64° 53.36340 W
Coral Area 2/CA2	9	0.11	17° 39.28320 N	64° 53.05140 W
Coral Area 2/CA2	10	0.11	17° 39.12060 N	64° 53.20500 W
Coral Area 3/CA3	1	0.03	17° 40.29060 N	64° 49.97460 W
Coral Area 3/CA3	2	0.03	17° 40.24440 N	64° 50.31540 W
Coral Area 3/CA3	3	0.03	17° 40.28880 N	64° 50.14620 W
Coral Area 3/CA3	4	0.03	17° 40.23300 N	64° 49.88700 W
Coral Area 3/CA3	5	0.03	17° 40.17180 N	64° 50.21460 W
Coral Area 3/CA3	6	0.03	17° 40.18560 N	64° 49.99260 W
Coral Area 3/CA3	7	0.03	17° 40.21380 N	64° 49.83960 W

Table A-2. Survey Locations for VIRIL Coral Disease Observations of Far Field and Background Locations				
SAMPLE AREA/ STATION DESIGNATION	SAMPLE NUMBER	HEXAGON SIZE (NM ^{2})	LATITUDE	LONGITUDE
Coral Area 3/CA3	8	0.03	17° 40.15320 N	64° 50.11260 W
Coral Area 3/CA3	9	0.03	17° 40.17120 N	64° 49.75680 W
Coral Area 3/CA3	10	0.03	17° 40.03860 N	64° 50.08500 W
Coral Area 4/CA4	1	0.22	17° 42.04080 N	64° 40.71300 W
Coral Area 4/CA4	2	0.22	17° 41.99760 N	64° 40.32660 W
Coral Area 4/CA4	3	0.22	17° 42.00660 N	64° 41.02680 W
Coral Area 4/CA4	4	0.22	17° 41.82600 N	64° 40.48200 W
Coral Area 4/CA4	5	0.22	17° 42.00120 N	64° 39.98940 W
Coral Area 4/CA4	6	0.22	17° 41.82660 N	64° 41.16600 W
Coral Area 4/CA4	7	0.22	17° 41.79360 N	64° 40.79640 W
Coral Area 4/CA4	8	0.22	17° 41.71140 N	64° 40.12980 W
Coral Area 4/CA4	9	0.22	17° 41.65920 N	64° 40.80660 W
Coral Area 4/CA4	10	0.22	17° 41.66760 N	64° 40.36800 W
Coral Area 5/CA5	1	0.31	17° 49.01020 N	64° 37.32600 W
Coral Area 5/CA5	2	0.31	17° 47.89260 N	64° 37.12320 W
Coral Area 5/CA5	3	0.31	17° 47.68080 N	64° 37.18020 W
Coral Area 5/CA5	4	0.31	17° 47.71560 N	64° 36.61680 W
Coral Area 5/CA5	5	0.31	17° 47.40240 N	64° 36.54720 W
Coral Area 5/CA5	6	0.31	17° 47.11260 N	64° 36.55320 W
Coral Area 5/CA5	7	0.31	17° 47.31960 N	64° 35.85600 W
Coral Area 5/CA5	8	0.31	17° 46.94820 N	64° 36.14520 W
Coral Area 5/CA5	9	0.31	17° 47.01600 N	64° 35.82480 W
Coral Area 5/CA5	10	0.31	17° 46.82880 N	64° 35.60040 W

Appendix A-3. Matrix of Transect Sampling and Observation Locations

Sample Station	Light Penetration and WQ Monitoring	Turbidity Sample	Color Sample	Five-Day BOD	COD Sample	Europhication Nutrient Sam	TOC	Acute Toxicity Sample	Statistical Observations of Coral Disease	Sea Grasses/Benthic Macroinvertebrates Sample	Grain Size Sample	Morphological Analysis Sample
V1 A	6											
V1 B	6	2										
V1 C	6	2	2	1	1	1	1	1				1
V1 D	6	2										
V1 E	6											
V2 A	6											
V2 B	6	2										
V2 C	6	2	2	1	1	1	1	1				1
V2 D	6	2										
V2 E	6											
N1 A	6											
N1 B	6	2										
N1 C	6	2	2	1	1	1	1	1		9	3	
N1 D	6	2										
N1 E	6											
N2 A	6											
N2 B	6	2										
N2 C	6	2	2							9	3	
N2 D	6	2										
N2 E	6											
N3 A	6											
N3 B	6	2										
N3 C	6	2	2	1	1	1	1	1		9	3	
N3 D	6	2										
N3 E	6											
N4 A	6											
N4 B	6	2										
N4 C	6	2	2							9	3	
N4 D	6	2										
N4 E	6											
N5 A	6											
N5 B	6	2										
N5 C	6	2	2	1	1	1	1	1		9	3	1
N5 D	6	2										
N5 E	6											
F1 A	6											
F1 B	6	2										
F1 C	6	2	2	1	1	1	1	1		9	3	
F1 D	6	2										
F1 E	6											
F2 A	6											
F2 B	6	2										
F2 C	6	2	2							9	3	
F2 D	6	2										
F2 E	6											
F3 A	6											
F3 B	6	2										
F3 C	6	2	2	1	1	1	1	1		9	3	
F3 D	6	2										
F3 E	6											
F4 A	6											
F4 B	6	2										
F4 C	6	2	2							9	3	
F4 D	6	2										
F4 E	6											
F5 A	6											
F5 B	6	2										
F5 C	6	2	2	1	1	1	1	1	1	9	3	1
F5 D	6	2										
F5 E	6											
RA1 A	6											
RA1 B	6											
RA1 C	6	2		1	1	1	1	2	1	9	3	
RA1 D	6											
RA1 E	6											
RA2 A	6											
RA2 B	6											
RA2 C	6	2		1	1	1	1	2	1	9	3	
RA2 D	6											
RA2 E	6											
CA1									1			
CA2									1			
CA3									1			
CA4									1			
CA5									1			
PR1												1
PR2												1
EF 1								2				1
TOTAL	420	76	24	10	10	10	10	14	8	108	36	7

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Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
V1 A	0	17	41087N	64	49140W	26.04	7.88	6.03	36.02	498	307.3
V1 A	1					26.04	7.88	6.1	36.02	634.6	355.9
V1 A	2					26.04	7.88	6.14	36.02	576.8	270.9
V1 A	3					26.04	7.88	6.15	36.02	573	252
V1 A	4					26.04	7.89	6.13	36.03	511.2	162.1
V1 A	5										
V1 A	6										
V1 B	0	17	40994N	64	49141W	26.07	7.85	5.81	36.05	720.6	309.4
V1 B	1					26.07	7.86	5.82	36.03	732.7	264.1
V1 B	2					26.08	7.86	5.87	36.03	607.5	165.2
V1 B	3					26.07	7.86	5.84	36.03	561.4	68.68
V1 B	4					26.07	7.86	5.8	36.03	375.7	27.27
V1 B	5					26.07	7.86	5.79	36.03	506.8	22.2
V1 B	6										
V1 C	0	17	40943N	64	49143W	26.05	7.81	5.51	36.05	591.6	124.6
V1 C	1					26.06	7.78	5.53	36.04	494.8	75.43
V1 C	2					26.05	7.81	5.6	36.05	627.8	48.37
V1 C	3					26.05	7.8	5.63	36.05	652.8	28.77
V1 C	4					26.05	7.78	5.6	36.06	665.9	11.26
V1 C	5					26.05	7.8	5.55	36.06	662.6	5.19
V1 C	6					26.06	7.7	5.17	36.04	604.2	2.13
V1 D	0	17	40905N	64	49148W	26.05	7.79	5.73	36.05	257.1	198.1
V1 D	1					26.05	7.79	5.7	36.05	220.7	85.17
V1 D	2					26.06	7.79	5.72	36.07	267.9	78.02
V1 D	3					26.05	7.79	5.82	36.06	213.6	45.71
V1 D	4					26.06	7.8	5.84	36.06	210.2	26.26
V1 D	5					26.05	7.8	5.78	36.07	253.9	17.71
V1 D	6					26.06	7.8	5.82	36.06	260.2	16.19
V1 E	0	17	40767N	64	49142W	26.11	7.88	6.28	36.05	1822	1724
V1 E	1					26.1	7.88	6.23	36.07	2348	1512
V1 E	2					26.1	7.88	6.27	36.06	2376	1578
V1 E	3					26.11	7.88	6.2	36.06	2072	984.1
V1 E	4					26.1	7.88	6.2	36.07	1263	599.5
V1 E	5					26.1	7.88	6.25	36.06	654.8	208.6
V1 E	6					26.11	7.88	6.17	36.05	628.8	176.5
V2 A	0	17	40989N	64	49157W	26.16	7.83	5.68	36	537.3	358.9
V2 A	1					26.16	7.84	5.79	36	1351	223.6
V2 A	2					26.16	7.85	5.82	36	388.9	192.1
V2 A	3					26.17	7.86	5.93	35.99	769.4	392.9
V2 A	4					26.16	7.86	5.94	36	1148	499.4
V2 A	5					26.17	7.86	5.93	36	1928	470
V2 A	6										
V2 B	0										
V2 B	1										
V2 B	2										

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
V2 B	3										
V2 B	4										
V2 B	5										
V2 B	6										
V2 C	0	17	40943N	64	49156W	26.15	7.89	5.84	36.07	281.6	172.1
V2 C	1					26.14	7.89	5.77	36.08	498.1	200.1
V2 C	2					26.15	7.89	5.87	36.06	2264	705.5
V2 C	3					26.14	7.88	5.93	36.07	2376	547.8
V2 C	4					26.15	7.88	5.96	36.05	2398	588.6
V2 C	5					26.14	7.88	6.03	36.05	1585	123
V2 C	6										
V2 D	0										
V2 D	1										
V2 D	2										
V2 D	3										
V2 D	4										
V2 D	5										
V2 D	6										
V2 E	0	17	40859N	64	49156W	26.22	7.88	6	35.99	1213	878.6
V2 E	1					26.22	7.88	5.99	35.99	1705	688.6
V2 E	2					26.22	7.88	6.09	35.98	1719	696.7
V2 E	3					26.21	7.87	6.19	36	1670	735.4
V2 E	4					26.21	7.87	6.22	36	1580	675.6
V2 E	5					26.21	7.88	6.22	36	1655	347.3
V2 E	6										
N1 A	0					26.15	7.87	5.96	36	318.6	211
N1 A	1					26.15	7.87	6.09	35.99	324.9	223.5
N1 A	2					26.15	7.87	6.11	35.99	304.2	107.1
N1 A	3					26.15	7.87	6.12	36.01	279.8	101.6
N1 A	4					26.15	7.87	6.11	35.99	277.2	115.8
N1 A	5					26.15	7.87	6.14	35.99	278.7	96.56
N1 A	6										
N1 B	0										
N1 B	1										
N1 B	2										
N1 B	3										
N1 B	4										
N1 B	5										
N1 B	6										
N1 C	0	17	40917N	64	49211W	26.2	7.87	6.25	36.03	567.7	236.5
N1 C	1					26.2	7.86	6.24	35.97	585.2	158.1
N1 C	2					26.21	7.87	6.19	35.97	421.9	180.4
N1 C	3					26.2	7.88	6.23	35.99	401	135.5
N1 C	4					26.2	7.88	6.23	36	452.6	63.22
N1 C	5					26.21	7.84	6.15	35.99	327.8	26.06

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
N1 C	6										
N1 D	0										
N1 D	1										
N1 D	2										
N1 D	3										
N1 D	4										
N1 D	5										
N1 D	6										
N1 E	0	17	40849N	64	49211W	26.23	7.91	6.4	36.03	290	244.7
N1 E	1					26.23	7.9	6.39	36.03	292.9	179
N1 E	2					26.23	7.9	6.35	36	275.9	130.5
N1 E	3					26.23	7.9	6.41	36	260.3	124.3
N1 E	4					26.23	7.9	6.39	36.01	250.5	94.05
N1 E	5					26.23	7.9	6.41	36	234.4	74.48
N1 E	6										
N2 A	0	17	41007N	64	49279W	26.3	7.92	6.24	36.1	2137	284.6
N2 A	1					26.29	7.93	6.32	36.09	1872	258.8
N2 A	2					26.29	7.95	6.34	36.1	1898	280.8
N2 A	3					26.29	7.95	6.31	36.11	1761	369.3
N2 A	4					26.3	7.96	6.41	36.1	1720	240.8
N2 A	5					26.31	7.96	6.42	36.09	1278	345.5
N2 A	6										
N2 B	0										
N2 B	1										
N2 B	2										
N2 B	3										
N2 B	4										
N2 B	5										
N2 B	6										
N2 C	0	17	40906N	64	49279W	26.29	7.94	6.21	36.1	1836	179
N2 C	1					26.26	7.88	6.18	36.1	1964	44.05
N2 C	2					26.28	7.96	6.31	36.11	1905	51.37
N2 C	3					26.26	7.94	6.33	36.09	1952	25.39
N2 C	4					26.27	7.85	6.25	36.1	1870	17.9
N2 C	5					26.26	7.81	6.23	36.11	1928	10.97
N2 C	6										
N2 D	0										
N2 D	1										
N2 D	2										
N2 D	3										
N2 D	4										
N2 D	5										
N2 D	6										
N2 E	0	17	40817N	64	49279W	26.22	7.96	6.22	36.12	1977	208.6
N2 E	1					26.22	7.96	6.33	36.13	1836	142.1

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude	Longitude	Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
N2 E	2			26.22	7.96	6.38	36.12	1944	153.1
N2 E	3			26.21	7.96	6.42	36.11	1978	253.4
N2 E	4			26.22	7.97	6.44	36.12	1736	510.3
N2 E	5			26.22	7.97	6.53	36.13	1900	731.1
N2 E	6								
N3 A	0	17 41973N	64 49366W	26.19	7.86	6.04	36.06	1716	294.4
N3 A	1			26.18	7.88	6.11	36.06	1337	331.4
N3 A	2			26.19	7.91	6.11	36.06	1622	213.3
N3 A	3			26.18	7.92	6.11	36.07	1433	277.3
N3 A	4			26.18	7.92	6.09	36.05	1667	323.4
N3 A	5			26.19	7.93	6.14	36.07	1181	377
N3 A	6								
N3 B	0								
N3 B	1								
N3 B	2								
N3 B	3								
N3 B	4								
N3 B	5								
N3 B	6								
N3 C	0	17 40878N	64 49366W	26.3	7.91	6.26	36.05	1766	335.2
N3 C	1			26.29	7.92	6.3	36.11	1015	74.66
N3 C	2			26.28	7.94	6.32	36.09	1066	35.08
N3 C	3			26.28	7.91	6.29	36.11	1064	20.46
N3 C	4			26.27	7.91	6.32	36.09	1175	9.92
N3 C	5			26.27	7.9	6.31	36.1	1395	5.75
N3 C	6								
N3 D	0								
N3 D	1								
N3 D	2								
N3 D	3								
N3 D	4								
N3 D	5								
N3 D	6								
N3 E	0	17 40809N	64 49366W	26.26	7.97	6.45	36.1	552.4	340.3
N3 E	1			26.26	7.97	6.53	36.1	906.4	192.2
N3 E	2			26.24	7.97	6.54	36.12	927.5	404.6
N3 E	3			26.26	7.97	6.64	36.11	1200	433
N3 E	4			26.25	7.97	6.64	36.1	1262	320.1
N3 E	5			26.26	7.98	6.66	36.09	1183	452.4
N3 E	6			26.25	7.97	6.6	36.12	1521	383.4
N4 A	0	17 40953N	64 49468W	25.94	7.83	5.86	36.23	1191	840.7
N4 A	1			25.95	7.84	5.89	36.24	1159	717.4
N4 A	2			25.94	7.85	5.92	36.23	1138	370.6
N4 A	3			25.95	7.85	5.88	36.23	1204	330.2
N4 A	4			25.95	7.86	5.92	36.23	1223	242

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
N4 A	5					25.94	7.86	5.95	36.23	1163	127.2
N4 A	6										
N4 B	0										
N4 B	1										
N4 B	2										
N4 B	3										
N4 B	4										
N4 B	5										
N4 B	6										
N4 C	0	17	40855N	64	49468W	26.3	7.94	6.17	36.09	1946	1108
N4 C	1					26.29	7.95	6.28	36.1	1994	464.3
N4 C	2					26.31	7.95	6.3	36.11	1915	177.3
N4 C	3					26.29	7.95	6.28	36.08	1942	120.8
N4 C	4					26.27	7.96	6.26	36.1	1932	70.3
N4 C	5					26.27	7.96	6.27	36.1	1992	48
N4 C	6					26.27	7.95	6.25	36.09	1929	19.19
N4 D	0										
N4 D	1										
N4 D	2										
N4 D	3										
N4 D	4										
N4 D	5										
N4 D	6										
N4 E	0	17	40750N	64	49468W	26.07	7.89	5.84	36.27	1284	770.7
N4 E	1					26.08	7.89	5.86	36.28	1261	829.5
N4 E	2					26.08	7.89	5.82	36.27	1275	718.3
N4 E	3					26.07	7.89	5.85	36.26	1240	456.3
N4 E	4					26.08	7.89	5.82	36.26	1314	447.9
N4 E	5					26.08	7.89	5.81	36.28	1238	310.1
N4 E	6					26.08	7.89	5.86	36.27	1284	273.4
N5 A	0	17	40915N	64	49570W	26.08	7.61	5.96	36.25	1701	1318
N5 A	1					26.1	7.65	5.91	36.26	1646	949.9
N5 A	2					26.1	7.71	6.02	36.24	1668	701.6
N5 A	3					26.07	7.75	6.06	36.23	1755	594.2
N5 A	4					26.06	7.78	6.03	36.24	1786	449.4
N5 A	5					26.06	7.83	6.08	36.24	1632	219.8
N5 A	6										
N5 B	0										
N5 B	1										
N5 B	2										
N5 B	3										
N5 B	4										
N5 B	5										
N5 B	6										
N5 C	0	17	40820N	64	49570W	26.1	7.82	5.67	36.26	1371	1090

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude	Longitude	Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
N5 C	1			26.11	7.84	5.67	36.27	1426	368.4
N5 C	2			26.1	7.85	5.74	36.25	1479	165.5
N5 C	3			26.12	7.88	5.9	36.26	1430	110.6
N5 C	4			26.12	7.88	5.72	36.25	1506	47.06
N5 C	5			26.09	7.88	5.64	36.23	1440	13.48
N5 C	6								
N5 D	0								
N5 D	1								
N5 D	2								
N5 D	3								
N5 D	4								
N5 D	5								
N5 D	6								
N5 E	0	17 40695N	64 49570W	26.18	7.91	6.03	36.28	1847	1452
N5 E	1			26.18	7.91	5.98	36.27	1726	1275
N5 E	2			26.19	7.91	6.04	36.27	1836	899.6
N5 E	3			26.18	7.91	6.01	36.26	1732	818.4
N5 E	4			26.19	7.91	6.02	36.27	1822	638
N5 E	5			26.19	7.92	6.02	36.27	1762	376.7
N5 E	6								
F1 A	0	17 40658W	64 50449W	26.5	7.94	6.34	36.2	1721	1400
F1 A	1			26.5	7.94	6.36	36.19	1726	1054
F1 A	2			26.5	7.94	6.43	36.2	1674	940.8
F1 A	3			26.51	7.95	6.47	36.19	1598	480.6
F1 A	4								
F1 A	5								
F1 A	6								
F1 B	0	17 40548N	64 50449W	26.53	7.88	5.57	36.23	1854	1414
F1 B	1			26.53	7.9	5.6	36.22	1894	619.4
F1 B	2			26.52	7.9	5.61	36.22	1859	304.7
F1 B	3			26.52	7.91	5.64	36.23	1994	179
F1 B	4			26.51	7.92	5.64	36.23	1806	138
F1 B	5								
F1 B	6								
F1 C	0	17 40552N	64 50449W	26.51	7.85	5.48	36.24	1956	1155
F1 C	1			26.5	7.86	5.45	36.23	1984	695
F1 C	2			26.5	7.87	5.48	36.23	1971	342.9
F1 C	3			26.48	7.88	5.46	36.23	2002	155.6
F1 C	4			26.47	7.89	5.46	36.23	1934	77.67
F1 C	5								
F1 C	6								
F1 D	0	17 40508N	64 50449W	26.48	7.91	5.5	36.24	1899	1208
F1 D	1			26.49	7.92	5.51	36.23	1920	666.1
F1 D	2			26.48	7.92	5.56	36.24	1816	334.3
F1 D	3			26.47	7.92	5.54	36.23	1795	184.2

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
F1 D	4					26.47	7.92	5.53	36.23	1790	79.98
F1 D	5										
F1 D	6										
F1 E	0	17	40413N	64	50449W	26.45	7.94	6.11	36.25	1763	1550
F1 E	1					26.44	7.95	6.14	36.24	1734	1262
F1 E	2					26.44	7.95	6.16	36.23	1832	743.5
F1 E	3					26.44	7.96	6.19	36.24	1813	669.4
F1 E	4					26.45	7.96	6.21	36.25	1725	521.6
F1 E	5					26.45	7.96	6.21	36.23	1800	511.4
F1 E	6					26.45	7.97	6.24	36.24	1748	429.5
F2 A	0	17	40939N	64	51189W	26.7	8.02	6.76	36.19	1546	1350
F2 A	1					26.69	8.02	6.78	36.19	1540	935.2
F2 A	2					26.68	8.01	6.79	36.19	1556	537.4
F2 A	3					26.68	8	6.8	36.19	1591	368.4
F2 A	4					26.68	8	6.84	36.19	1456	312.8
F2 A	5										
F2 A	6										
F2 B	0	17	40836W	64	51189W	26.53	7.94	5.93	36.17	1628	1116
F2 B	1					26.53	7.95	5.94	36.17	1570	808.6
F2 B	2					26.54	7.95	6.01	36.18	1679	688.7
F2 B	3					26.53	7.95	5.96	36.18	1679	225.7
F2 B	4					26.52	7.94	5.91	36.18	1636	177.9
F2 B	5										
F2 B	6										
F2 C	0	17	40824N	64	51189W	26.52	7.92	5.7	36.18	1677	1370
F2 C	1					26.5	7.93	5.73	36.2	1625	713.7
F2 C	2					26.51	7.93	5.81	36.18	1763	592.4
F2 C	3					26.5	7.93	5.74	36.19	1690	252.5
F2 C	4					26.5	7.94	5.77	36.19	1784	145.4
F2 C	5										
F2 C	6										
F2 D	0	17	40810N	64	51189W	26.55	7.91	5.87	36.17	1621	1156
F2 D	1					26.55	7.91	5.91	36.18	1663	742.6
F2 D	2					26.54	7.92	5.9	36.19	1616	491.1
F2 D	3					26.55	7.93	5.94	36.18	1674	260.5
F2 D	4					26.54	7.93	5.97	36.19	1678	164.4
F2 D	5										
F2 D	6										
F2 E	0	17	40676N	64	50189W	26.55	7.93	6.17	36.2	1579	1324
F2 E	1					26.55	7.94	6.18	36.21	1629	838.5
F2 E	2					26.55	7.94	6.23	36.21	1627	745.9
F2 E	3					26.54	7.95	6.21	36.21	1642	520.1
F2 E	4					26.54	7.95	6.26	36.21	1526	426.2
F2 E	5					26.54	7.95	6.29	36.21	1600	302
F2 E	6										

Table A-4 Hydrographic Profile Data

Sample Station		Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
F3	A	0	17	40820N	64	51900W	26.19	7.73	6	36.25	1444	1317
F3	A	1					26.2	7.73	6.13	36.25	1710	410.7
F3	A	2					26.2	7.74	6.2	36.25	606.5	233.1
F3	A	3					26.19	7.74	6.21	36.26	1346	221.2
F3	A	4					26.19	7.74	6.26	36.25	1686	247.1
F3	A	5					26.19	7.74	6.26	36.24	1024	135.3
F3	A	6										
F3	B	0	17	40655N	64	51900W	26.24	7.7	5.49	36.28	1390	747.3
F3	B	1					26.23	7.7	5.5	36.27	1286	544.6
F3	B	2					26.23	7.69	5.51	36.28	1321	339.4
F3	B	3					26.24	7.69	5.53	36.26	1217	79.73
F3	B	4					26.22	7.68	5.55	36.27	1128	49.81
F3	B	5					26.22	7.68	5.44	36.27	1372	54.34
F3	B	6					26.22	7.68	5.52	36.27	1307	49.04
F3	C	0	17	40612N	64	41900W	26.2	7.69	5.42	36.29	1142	647.3
F3	C	1					26.2	7.7	5.44	36.28	1154	614.2
F3	C	2					26.19	7.71	5.41	36.29	1054	442.6
F3	C	3					26.19	7.71	5.46	36.28	1121	235.8
F3	C	4					26.19	7.7	5.44	36.28	1239	118.3
F3	C	5					26.19	7.7	5.43	36.29	1167	78.51
F3	C	6					26.19	7.69	5.41	36.27	1211	51.91
F3	D	0	17	40570N	64	51900W	26.18	7.69	5.55	36.3	1127	779.4
F3	D	1					26.17	7.68	5.61	36.28	1757	749.8
F3	D	2					26.18	7.68	5.65	36.28	1648	421.8
F3	D	3					26.18	7.68	5.66	36.29	1576	335.1
F3	D	4					26.18	7.68	5.6	36.3	1348	158.9
F3	D	5					26.18	7.68	5.58	36.29	1400	106.8
F3	D	6					26.17	7.68	5.54	36.28	1152	66.67
F3	E	0	17	40400N	64	51900W	26.19	7.73	6.05	36.29	1829	1573
F3	E	1					26.19	7.72	6.11	36.31	1820	1160
F3	E	2					26.19	7.73	6.14	36.29	1775	634.6
F3	E	3					26.19	7.73	6.12	36.3	1811	648.2
F3	E	4					26.19	7.73	6.15	36.28	1884	566.8
F3	E	5					26.19	7.74	6.17	36.3	1847	366.7
F3	E	6					26.19	7.74	6.17	36.29	1679	440.6
F3	E	7					26.19	7.74	6.18	36.28	885	273.5
F4	A	0	17	40900N	64	52600W	26.26	7.71	6.04	36.18	877.4	617.8
F4	A	1					26.25	7.72	6.06	36.17	928	468.4
F4	A	2					26.26	7.73	6.09	36.17	934.1	245.8
F4	A	3					26.24	7.73	6.1	36.15	1340	139.8
F4	A	4					26.21	7.73	6.11	36.16	1308	77.4
F4	A	5					26.19	7.73	6.09	36.16	2332	32.41
F4	A	6										
F4	B	0	17	40756N	64	52600W	26.29	7.73	6.31	36.24	2180	1363
F4	B	1					26.3	7.73	5.79	36.24	1712	973.8

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
F4 B	2					26.29	7.74	5.83	36.24	1769	431.3
F4 B	3					26.29	7.74	5.87	36.25	1259	394.8
F4 B	4					26.27	7.74	5.89	36.25	1742	237.1
F4 B	5					26.27	7.74	5.88	36.25	1904	143.7
F4 B	6										
F4 C	0	17	40725N	64	52600W	26.25	7.51	5.89	36.24	629.5	309.7
F4 C	1					26.25	7.56	5.88	36.26	704.2	261.5
F4 C	2					26.24	7.57	5.86	36.25	716.8	164.9
F4 C	3					26.24	7.6	5.85	36.25	716.7	113
F4 C	4					26.24	7.62	5.89	36.24	754.2	93.27
F4 C	5					26.24	7.64	5.88	36.25	684.5	70.24
F4 C	6										
F4 D	0	17	40700N	64	52600W	26.23	7.68	5.84	36.25	799.5	526.5
F4 D	1					26.23	7.69	5.81	36.25	843.8	401.7
F4 D	2					26.23	7.7	5.84	36.26	908.6	301.8
F4 D	3					26.23	7.71	5.85	36.25	875.6	215.9
F4 D	4					26.23	7.71	5.81	36.25	864.3	150.8
F4 D	5					26.23	7.71	5.86	36.25	1001	103.7
F4 D	6										
F4 E	0	17	40330N	64	52600W	26.21	7.72	6.15	36.3	699.2	429
F4 E	1					26.21	7.73	6.21	36.31	681.6	390
F4 E	2					26.21	7.74	6.28	36.31	710.8	308.5
F4 E	3					26.21	7.74	6.32	36.3	725.6	281.5
F4 E	4					26.21	7.75	6.32	36.3	722.9	236.5
F4 E	5					26.21	7.75	6.33	36.3	712.7	202.5
F4 E	6					26.22	7.75	6.32	36.3	773.9	176.8
F5 A	0	17	40682N	64	53300W	25.77	7.95	6.19	36.35	1104	1200
F5 A	1					25.79	7.95	6.21	36.36	1133	421
F5 A	2					25.8	7.95	6.27	36.33	1047	287
F5 A	3					25.81	7.95	6.3	36.36	1787	375
F5 A	4										
F5 A	5										
F5 A	6										
F5 B	0	17	40563N	64	53300W	25.9	7.94	5.82	36.36	1458	924.2
F5 B	1					25.89	7.94	5.83	36.35	1736	793.1
F5 B	2					25.89	7.94	5.8	36.36	1441	477.6
F5 B	3					25.89	7.94	5.89	36.37	1697	241.6
F5 B	4										
F5 B	5										
F5 B	6										
F5 C	0	17	40527N	64	53300W	25.89	7.94	5.87	36.37	453.5	292
F5 C	1					25.89	7.94	5.81	36.36	330.6	131.8
F5 C	2					25.89	7.94	5.86	36.37	284.5	53.35
F5 C	3					25.89	7.94	5.84	36.36	366.9	85.11
F5 C	4										

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude	Longitude	Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
F5 C	5								
F5 C	6								
F5 D	0	17 40509N	64 49300W	25.89	7.96	6.03	36.37	1137	706.8
F5 D	1			25.89	7.96	6.04	36.36	465.7	162.3
F5 D	2			25.89	7.96	6.05	36.37	469	104.8
F5 D	3			25.89	7.96	6.11	36.37	426.5	62.01
F5 D	4								
F5 D	5								
F5 D	6								
F5 E	0	17 40382N	64 53300W	25.9	8	6.34	36.36	505	275.1
F5 E	1			25.9	8	6.38	36.36	523.3	135.4
F5 E	2			25.91	7.99	6.37	36.35	522.5	161.1
F5 E	3			25.91	7.99	6.49	36.37	611.2	112.2
F5 E	4								
F5 E	5								
F5 E	6								
RA1 A	0	17 41996N	64 40190W	26.39	8.15	6.21	36.32	1577	1141
RA1 A	1			26.39	8.15	6.19	36.32	1651	971.6
RA1 A	2			26.38	8.15	6.16	36.33	1570	515.6
RA1 A	3			26.38	8.15	6.16	36.33	1559	540.3
RA1 A	4			26.38	8.15	6.18	36.33	1596	319.3
RA1 A	5			26.38	8.15	6.17	36.32	1526	434.4
RA1 A	6			26.38	8.15	6.17	36.3	1572	450
RA1 A	7			26.38	8.15	6.19	36.32	1680	393.6
RA1 A	8			26.39	8.15	6.15	36.33	1639	360.2
RA1 B	0	17 41950N	64 40190W	26.38	8.13	6.04	36.34	1769	1168
RA1 B	1			26.38	8.14	5.96	36.32	1685	1081
RA1 B	2			26.37	8.13	5.93	36.32	1804	892.2
RA1 B	3			26.37	8.13	6.01	36.34	1869	686.1
RA1 B	4			26.37	8.14	5.92	36.33	1984	809.1
RA1 B	5			26.36	8.13	5.92	36.33	1836	667.5
RA1 B	6			26.37	8.13	5.93	36.33	1931	469
RA1 B	7			26.36	8.13	5.93	36.32	1870	520.5
RA1 B	8			26.36	8.14	5.92	36.33	1935	535
RA1 C	0	17 41935N	64 40190W	26.36	8.15	6.14	36.33	1746	380.6
RA1 C	1			26.37	8.15	6.13	36.33	1905	694.2
RA1 C	2			26.37	8.15	6.09	36.32	431.2	221.7
RA1 C	3			26.37	8.15	6.11	36.32	847	910.9
RA1 C	4			26.37	8.15	6.13	36.33	1578	877.1
RA1 C	5			26.37	8.14	6.11	36.31	1703	690.2
RA1 C	6			26.36	8.14	6.12	36.33	1757	730.5
RA1 C	7			26.37	8.14	6.17	36.33	1847	227.2
RA1 C	8			26.36	8.14	6.19	36.32	1894	350.2
RA1 D	0	17 41918N	64 40190W	26.37	8.15	6.03	36.31	447.5	415.8
RA1 D	1			26.37	8.14	6	36.3	1923	1181

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
RA1 D	2					26.37	8.15	6.03	36.33	1833	642.6
RA1 D	3					26.37	8.15	6.01	36.33	999.8	220.2
RA1 D	4					26.37	8.15	6.02	36.32	354.2	139
RA1 D	5					26.39	8.14	6.05	36.32	1860	514.7
RA1 D	6					26.38	8.14	6.06	36.33	1741	348.8
RA1 D	7					26.38	8.14	6.04	36.33	1717	451.3
RA1 D	8					26.37	8.14	6.05	36.31	1788	177
RA1 E	0	17	41873N	64	40190W	26.39	8.14	6.33	36.33	1777	998.4
RA1 E	1					26.39	8.14	6.13	36.34	516.4	275.2
RA1 E	2					26.38	8.14	6.19	36.34	390.1	187.6
RA1 E	3					26.39	8.14	6.14	36.32	400	179.5
RA1 E	4					26.39	8.14	6.14	36.33	382	138.7
RA1 E	5					26.38	8.14	6.17	36.34	508.4	195.4
RA1 E	6					26.38	8.14	6.16	36.32	461.1	150
RA1 E	7					26.38	8.15	6.17	36.32	529	166.9
RA1 E	8					26.38	8.14	6.23	36.33	691.3	255.2
RA2 A	0	17	41175	64	46629	25.98	8.1	5.87	36.39	1939	1451
RA2 A	1					25.96	8.1	5.79	36.38	1865	1406
RA2 A	2					25.96	8.1	5.88	36.4	1833	1115
RA2 A	3					25.95	8.1	5.89	36.39	1892	770
RA2 A	4					25.95	8.1	5.91	36.41	1814	712.9
RA2 A	5					25.93	8.1	5.93	36.39	1926	712.9
RA2 A	6					25.93	8.11	5.93	36.4	1871	546.3
RA2 B	0	17	41135N	64	46629W	25.91	8.09	5.69	36.4	1630	1592
RA2 B	1					25.89	8.09	5.69	36.4	1619	1121
RA2 B	2					25.9	8.09	5.66	36.4	1598	1008
RA2 B	3					25.9	8.09	5.68	36.41	1610	835.8
RA2 B	4					25.9	8.09	5.71	36.4	1613	305.1
RA2 B	5					25.9	8.09	5.67	36.41	1524	390.1
RA2 B	6					25.91	8.09	5.7	36.39	1492	472.6
RA2 B	7					25.91	8.1	5.66	36.41	1548	504
RA2 C	0	17	41117N	64	46629W	25.93	8.09	5.69	36.41	1657	1451
RA2 C	1					25.94	8.09	5.68	36.4	1702	952.9
RA2 C	2					25.95	8.09	5.68	36.41	1654	950.5
RA2 C	3					25.93	8.09	5.78	36.42	1711	423.5
RA2 C	4					25.93	8.09	5.76	36.41	1794	725
RA2 C	5					25.92	8.1	5.82	36.41	1687	734.6
RA2 C	6					25.91	8.1	5.82	36.4	1725	707.2
RA2 C	7					25.95	8.1	5.91	36.41	1714	439.2
RA2 D	0	17	41103N	64	46629W	25.89	8.07	5.77	36.41	1571	1196
RA2 D	1					25.88	8.07	5.73	36.4	1651	1205
RA2 D	2					25.88	8.07	5.7	36.41	1581	1056
RA2 D	3					25.88	8.08	5.71	36.41	1657	879.7
RA2 D	4					25.88	8.08	5.66	36.41	1622	933.4
RA2 D	5					25.88	8.08	5.68	36.41	1657	563.3

Table A-4 Hydrographic Profile Data

Sample Station	Depth (m)	Latitude		Longitude		Temp	pH	DO	Salinity	Light (Amb)	Light (UW)
RA2 D	6					25.89	8.08	5.73	36.4	1542	599.6
RA2 D	7					25.9	8.09	5.78	36.4	1609	218.7
RA2 E	0	17	41067N	64	46629W	25.94	8.1	5.68	36.41	1722	1311
RA2 E	1					25.96	8.1	5.79	36.4	1818	900.6
RA2 E	2					25.92	8.1	5.75	36.4	362	208.7
RA2 E	3					25.94	8.1	5.69	36.4	357.1	180.6
RA2 E	4					25.91	8.1	5.75	36.4	422	148.1
RA2 E	5					25.91	8.1	5.81	36.4	414.7	153
RA2 E	6					25.91	8.1	5.8	36.39	907.4	380.2
RA2 E	7					25.91	8.1	5.88	36.39	1404	535.7

Table A-5. Spreadsheet of Light Attenuation Coefficients Calculation

TRANSECT	PROFILE	Intercept	K	_RSQ_	Zc=1.86/K
F1	A	-0.1357518	-0.3171071	0.8980072	5.866
F1	B	-0.4253328	-0.5992622	0.94867086	3.104
F1	C	-0.3991441	-0.7028105	0.99759126	2.647
F1	D	-0.3714322	-0.6664482	0.99657682	2.791
F1	E	-0.2345617	-0.2161513	0.90723446	8.605
F2	A	-0.1642074	-0.3838882	0.9516361	4.845
F2	B	-0.1929278	-0.5141754	0.92593159	3.617
F2	C	-0.1320563	-0.5805448	0.98274216	3.204
F2	D	-0.2677845	-0.5128576	0.99431803	3.627
F2	E	-0.2489132	-0.2794133	0.9693322	6.657
F3	A	-0.5025897	-0.3449847	0.7420259	5.392
F3	B	-0.5946854	-0.5228958	0.89781346	3.557
F3	C	-0.231588	-0.4834808	0.96230585	3.847
F3	D	-0.4022148	-0.4206975	0.99030337	4.421
F3	E	-0.4299599	-0.1618342	0.68038088	11.493
F4	A	-0.0169559	-0.7837617	0.9660516	2.373
F4	B	-0.2958938	-0.4242833	0.90878975	4.384
F4	C	-0.7247616	-0.3334462	0.9781714	5.578
F4	D	-0.3629857	-0.3640718	0.99289225	5.109
F4	E	-0.4484559	-0.1678288	0.99001207	11.083
F5	A	-0.1252128	-0.5346439	0.8618175	3.479
F5	B	-0.3155468	-0.4968439	0.94198216	3.744
F5	C	-0.5276066	-0.3908922	0.7773536	4.758
F5	D	-0.4858289	-0.493942	0.99028525	3.766
F5	E	-0.7270668	-0.3152163	0.75479276	5.901
N1	C	-0.668315	-0.3052618	0.69454966	6.093
N1	E	-0.2520313	-0.1830489	0.94255917	10.161
N2	A	-2.0774886	-0.1141085	0.53160031	16.300
N2	C	-2.7137192	-0.5044014	0.88499213	3.688
N2	E	-2.7366605	-0.3203013	0.74729651	5.807
N3	A	-1.8032692	-0.080069	0.23417376	23.230
N3	C	-1.7429871	-0.7579337	0.99323398	2.454
N3	E	-0.8669173	-0.07237	0.17279158	25.701
N4	A	-0.2361423	-0.3748259	0.97167008	4.962
N4	C	-0.7760799	-0.6348149	0.97782975	2.930
N4	E	-0.3250956	-0.2006897	0.9376491	9.268
N5	A	-0.1889695	-0.3317879	0.97100233	5.606
N5	C	-0.3046019	-0.8372087	0.97959273	2.222
N5	E	-0.1241746	-0.2552064	0.94101735	7.288
RA1	A	-0.5867145	-0.1337776	0.69414161	13.904
RA1	B	-0.4402529	-0.1244148	0.87430323	14.950
RA1	C	-0.667214	-0.0906349	0.14320944	20.522
RA1	D	-0.3457168	-0.2074571	0.75114491	8.966
RA1	E	-0.6052437	-0.0702652	0.82615554	26.471
RA2	A	-0.2223388	-0.169243	0.9357708	10.990

RA2	B	-0.2068016	-0.1833743	0.63247793	10.143
RA2	C	-0.3911592	-0.1254266	0.52506186	14.829
RA2	D	-0.0494608	-0.2064224	0.77110126	9.011
RA2	E	-0.4511496	-0.0881151	0.66426313	21.109
V1	A	-0.4320895	-0.161032	0.94166796	11.550
V1	B	-0.5921879	-0.4944986	0.96941677	3.761
V1	C	-1.2368356	-0.7129481	0.98854592	2.609
V1	D	-0.3596759	-0.4260869	0.97896968	4.365
V1	E	-0.1012467	-0.194315	0.946786	9.572
V2	A	-0.8230455	-0.0586237	0.04234448	31.728
V2	C	-0.3969739	-0.8626366	0.83615705	2.156
V2	E	-0.4627798	-0.1712933	0.63989171	10.859

Table A-6. Coral Reconnaissance for VIRIL Coral Disease Observations of Far Field Locations			
SAMPLE AREA/ STATION DESIGNATION	SAMPLE NUMBER	DESCRIPTION	DIVER
Coral Area 1/CA1	1	No coral.	Charles LoBue
Coral Area 1/CA1	2	No coral.	Charles LoBue
Coral Area 1/CA1	3	In plume.	None
Coral Area 1/CA1	4	In plume.	None
Coral Area 1/CA1	5	In plume.	None
Coral Area 1/CA1	6	In plume.	None
Coral Area 1/CA1	7	No coral.	Charles LoBue
Coral Area 1/CA1	8	Sandy bottom	Charles LoBue
Coral Area 1/CA1	9	No coral, 60-ft deep	Charles LoBue
Coral Area 1/CA1	10	No coral.	Charles LoBue
Coral Area 2/CA2	1	Sea grass, no coral.	Dan Cooke
Coral Area 2/CA2	2	Sea grass, no coral.	Dan Cooke
Coral Area 2/CA2	3	Sea grass, sparse coral.	Dan Cooke
Coral Area 2/CA2	4	Sea grass, no coral.	Dan Cooke
Coral Area 2/CA2	5	Sea grass, no coral.	Dan Cooke
Coral Area 2/CA2	6	Sandy bottom, no coral.	Dan Cooke
Coral Area 2/CA2	7	Sandy bottom, no coral.	Dan Cooke
Coral Area 2/CA2	8	Sandy bottom, no coral.	Dan Cooke
Coral Area 2/CA2	9	Sandy bottom, no coral.	Dan Cooke
Coral Area 2/CA2	10	No coral.	Dan Cooke
Coral Area 3/CA3	1	No coral.	Alan Humphrey
Coral Area 3/CA3	2	No coral.	Alan Humphrey
Coral Area 3/CA3	3	Light coral	Alan Humphrey
Coral Area 3/CA3	4	No coral.	Alan Humphrey
Coral Area 3/CA3	5	No coral.	Alan Humphrey

Table A-6. Coral Reconnaissance for VIRIL Coral Disease Observations of Far Field Locations			
SAMPLE AREA/ STATION DESIGNATION	SAMPLE NUMBER	DESCRIPTION	DIVER
Coral Area 3/CA3	6	No coral.	Alan Humphrey
Coral Area 3/CA3	7	Sand bottom.	Alan Humphrey
Coral Area 3/CA3	8	No coral.	Alan Humphrey
Coral Area 3/CA3	9	No coral.	Alan Humphrey
Coral Area 3/CA3	10	Sea grass.	Alan Humphrey

Attachment A-1

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2

MEMORANDUM TO FILE: VIRIL Ambient Monitoring Survey

SUBJECT: Ambient Monitoring of Virgin Island Rum Industries Ltd. Ocean Discharge

DATE: May 17, 2001

FROM Marcus Zobrist
Water Quality Team
Office of Wastewater Management
EPA - Office of Water

Charles LoBue
Dredged Material Management Team
Division of Environmental Planning and Protection
EPA Region 2

I. ANDERSON SURVEY MISSION OBJECTIVES

Background

The Caribbean Basin Economic Recovery Act (CBERA), a Federal law signed in 1983, contains the following provision exempting Virgin Islands Rum from certain portions of the Clean Water Act:

> *"Any discharge from a point source in the United States Virgin Islands in existence on the date of enactment of this subsection which discharge is attributable to the manufacture of rum (as defined in paragraphs (8) of section 7652(c) of the Internal Revenue Service Code of 1954) shall not be subject to the requirements of section 301(other than toxic pollutant discharges), section 306 or section 403 of the Federal Water Pollutant Control Act if-*
> *(1) such discharge occurs at least one thousand five hundred feet into the territorial sea from the line of ordinary low water from that portion of the coast which is in direct contact with the sea, and*
> *(2) the Governor of the United States Virgin Islands determines that such a discharge will not interfere with the attainment or maintenance of the water quality which shall assure the protection of public water supplies, and the protection and propagation of a balanced population of shellfish, fish, and wildlife, and allow recreational activities, in and on the waters and will not result in the discharge of pollutants in quantities which may reasonably be anticipated to pose an unacceptable risk to human health or the environment because of bioaccumulation, persistency in the environment, acute toxicity, chronic toxicity (including carcinogenicity, mutagenicity, or teratogenicity) or synergistic propensities".*

This provision applies uniquely to Virgin Islands Rum Industries Ltd. (VIRIL). It exempts the facility from the effluent limitations (section 301), national standards of performance (section 306), and ocean discharge criteria (section 403).

The objective of the Anderson Survey of the VIRIL discharge is to perform a preliminary assessment to provide information that would be useful in determining whether the VIRIL discharge is meeting the requirements of the exemption above. To facilitate this task, the survey was developed around the following six goals:

1. To document VIRIL's effluent quality. The effluent shall be sampled and analyzed for all parameters for which a permit limit is established for this discharge, for all Virgin Islands water quality standards, for all proposed EPA water quality standards for "healthy ocean waters" or all priority pollutants, and for certain indicator parameters and select other parameters which were notably high in previous EPA compliance monitoring inspections.

2. To document the location of all discharges from this facility, including any possible leaks for the underwater pipeline. To determine whether the point of discharge(s) complies with item one of the CBERA exemption above.

3. To document the fate and transport of the discharge plume after it leaves the outfall.

4. To document the attainment/non-attainment of water quality as a result of this discharge in the vicinity of the outfall, in vicinity of the plume, and in the area where the plume sinks from the surface and mixes with seawater.

5. To document whether a balanced population of shellfish, fish, and wildlife including coral reefs exists and can propagate in the vicinity of the outfall, discharge plume and in the vicinity of the area where the plume mixes with seawater. Included in this will be a visual observation of benthic communities in the vicinity of the outfall and the in the area where the plume sinks and mixes with the seawater.

6. To document whether the discharge poses an unacceptable risk to human health to persons conducting recreational activities, in and on the waters in the vicinity of the outfall, the plume or where the plume mixes with ambient waters.

The survey goals were set up to allow for documentation of the specified issues where field conditions were optimal for collecting conclusive data. However, actual plume properties were poorly understood, and it was expected the survey would provide vital reconnaissance for any possible further study. During the survey, ocean and discharge conditions during the survey were different than prevailing conditions understood from review of the background information. Conditions were different in the following ways:

> on the initial two days of the survey, the ocean current did not flow in a westerly direction, but a slight easterly direction;

on the initial two days of the survey, the visible plume profile was not in the usual west to east orientation, but spread locally around the end of the pipeline;
there was more than one pipeline in the vicinity of the outfall;
the water column orientation of the plume was at the bottom, as opposed to a surface plume;
the nature of the plume was turbidity and color as opposed to density, salinity, and chemical contamination.

Therefore, conditions were not conducive to fully documenting such aspects as: fate and transport of the plume; propagation of balanced populations of fish, wildlife, and coral reefs; and unacceptable risk to human health conducting recreational activities in the vicinity of the plume. While some of the documentation goals were not achieved, survey measurements and observations provided a preliminary assessment of plume properties and environmental conditions, which will enable scoping of a more definitive survey investigation.

II. ANDERSON SURVEY RESULTS

Presented below are the survey results that document the information gathered in response to each of the above survey objectives.

1. VIRIL effluent quality

For a complete discussion of VIRIL's facility, manufacturing process, process water, wastewater and sanitary waste production and disposal, TPDES permit effluent limitations, compliance evaluation inspection observation and finding and compliance sampling inspection results, and photos, see the Compliance Evaluation Inspection and Compliance Sampling Inspection (CSI) report, dated February 7, 2001. A summary of the inspection findings and sampling results is included below.

(A) Effluent Observations

The discharge at Outfall 001 was observed, during the CSI at the facility, to be dark reddish-brown in color and opaque, i.e., it was highly turbid. Some foam was observed floating on the discharge during the inspection. This foam was similar in appearance to the foam that was observed in the fermentation tanks.

(B) Analytical Results of Effluent Sampling:

The effluent temperature at the sampling location was measured on site by EPA personnel via a calibrated thermometer to be 39°C (102.2°F). An effluent grab sample and a duplicate were taken from the facility. Split samples were provided to facility personnel. All sample containers, preservatives and holding times were in accordance with 40 CFR Part 136. The samples were shipped via Federal Express to EPA Region 1's Environmental Science Laboratory in Lexington, Massachusetts for analysis.

Results of the effluent analysis of wastewater are contained in Table 1 below:

Table 1. Effluent Monitoring Results
Sampling conducted on November 6, 2000

Parameter	Concentration (µg/L)	Comments
Chemical Oxygen Demand	130,000,000	
Biochemical Oxygen Demand	51,800,000	Estimated Result[1]
Oil & Grease	26,000	
Total Suspended Solids	58,000,000	Estimated Result
Total Phosphorus	140,000	Estimated Result
Phenol	650	
Benzyl Alcohol	2,700	

All other parameters analyzed for were not detected. A complete explanation of the results can be found in the Compliance Evaluation Inspection and Compliance Sampling Inspection (CSI) report, dated February 7, 2001 (see attachment).

(C) Oil and Grease Effluent Limit Violation

Two grab samples, analyzed for the parameter oil and grease, showed effluent concentrations of 18 milligrams per liter (mg/L) and 26 mg/L. The sample type was in accordance with the permit. The results of these analysis indicate that the facility was in violation of the daily maximum permit limitation of 15 mg/L that is established in the permit.

The samples for chemical oxygen (COD) and total suspended solids (TSS) were grab samples and were not sampled in accordance with permit which requires 24-hr composite sampling. During the inspection, the effluent was not analyzed for pH, nor was flow measured.

(D) Discharge Monitoring Reports

VIRIL submits Discharge Monitoring Reports (DMRs) to EPA and VIDPNR on a quarterly basis as required by the permit. VIRIL has reported noncompliance with the effluent limitations of the

[1] Described in the Compliance Evaluation Inspection and Compliance Sampling Inspection (CSI) report, dated February 7, 2001 (see attachment).

TPDES permit. The table below lists the parameters that have been exceeded during the period beginning on January 1, 1997 (as presented in 11 DMRs) :

temperature:	6 violations
COD:	4 violations
pH:	1 violation
oil and grease:	1 violation

(E) Compliance Evaluation Inspection Observations and Findings

The following operation and maintenance, monitoring, effluent quality and other observations and findings were made during the inspection:

Cooling System Heat Exchanger Leak. A leak was observed in the cooling system heat exchanger that resulted in the discharge of copper sulfate bearing wastewater being discharged via outfall 001.

Foam. A significant quantity of foam is produced during fermentation and was visible in the fermentation tanks during the inspection.

Wastewater Treatment. As noted above, currently all wastewater is discharged without treatment. There is no operational wastewater treatment systems at the facility. However, VIRIL is currently in the process of installing treatment of the fermentor bottoms and treatment to remove excess heat.

(i) Anticipated Treatment for Removal of Excess Heat

Despite the existing use of heat exchangers, the discharge, especially from the distillation columns is regularly in excess of 30°C (86°F) and has been reported as high as 51.3°C (124.5°F). To remove further heat from the discharge, the facility has installed an open air cooling slide constructed from galvanized metal. The cooling slide was partially complete and not operational at the time of construction.

(ii) Anticipated Treatment of the Fermentor Bottoms

VIRIL is planning to install a treatment system that is expected to treat the fermentor bottoms wastewater stream prior to mixing with the mostos wastestream and other wastestreams and discharge via Outfall 001. The fermentor bottoms wastewater treatment system would comprise of two decantation tanks and a rotating vacuum filter press. Based in VIRIL's letter of March 28, 2001, the rotating drum vacuum filter was to be installed and started up in late April to early May, 2001.

2. Documentation of Pipeline Integrity

The VIRIL effluent travels from the facility via one of two pressurized four inch diameter force mains for transport approximately one mile south to the south coast of the Island. The force main is pressurized to 16 lbs./in^2. This pressurized pipeline began operation in approximately July 2000, replacing a gravity-fed 14-inch diameter bitumous clay pipe that was clogging. At the shoreline, the wastewater is transferred to an unpressurized 6-inch diameter ductile iron gravity line that travels partially buried approximately 1,900 feet from shore before discharging via the end of the pipe (there is no outfall diffuser) into Negro Bay. The discharge is in approximately 18 feet of water. According to VIRIL personnel, this pipe is thought to be partially clogged, however, no leaks are known at this time. In the vicinity of the current discharge pipeline are three to four disused pipelines that previously served as the VIRIL discharge pipeline. Each was discarded after becoming clogged or after rupturing. These are no longer connected to the VIRIL discharge Also in the vicinity is another abandoned steel pipeline that extends further from shore, this pipeline was used by Texaco to transfer oil products from ships moored off-shore to a former on-shore tank farm.

The underwater portion of the pipeline was inspected for any leaks. The integrity of the pipeline appeared to be good, and no signs of leakage were observed in the limited portion of visible pipeline. The location of the discharge was found to comply with exemptions to portions of the Clean Water Act found in the Caribbean Basin Economic Recovery Act.

3. Fate and transport of the discharge plume after it leaves the outfall

Once the discharge leaves the outfall, it entrains receiving waters and dilutes to form an effluent plume. The physical characteristics of the effluent, receiving water, diffuser design, and depth of discharge will determine the amount of effluent dilution achieved. Many ocean outfalls use a device called a diffuser to increase dilution, however at the VIRIL there is no diffuser and the effluent simply exits through the end of the pipeline.

The momentum and buoyancy of the discharged effluent is primarily responsible for the entrainment of dilution water (i.e., mixing of ambient saline water with effluent). As the plume rises and entrains ambient saline water, its density increases and its momentum and buoyancy decrease. The plume will rise until it reaches a level of neutral buoyancy (i.e, where the plume density equals ambient water density) in a zone of ambient stratification. If a sufficient density gradient is not present, no zone of ambient stratification occurs, and the diluted water will reach the water surface and then flow horizontally. A relatively low density (non-saline) and/or relatively high temperature effluent creates a buoyant plume that rises rapidly towards the water surface, entraining significant amounts of ambient saline water. The VIRIL effluent is of a high density, an effluent sample taken on November 6, 2000 as part of the compliance sampling inspection was measured via hand refractometer to be 1.06 specific gravity. The specific gravity of sea water in areas not impacted by the plume was also measured by hand refractometer to be 1.025. Thus, the effluent is relatively more dense than sea water and would tend to form a "bottom hugging plume." A high temperature would tend to decrease the effluent density, the VIRIL effluent at the discharge location is of very high relative temperature, as measured via a calibrated thermometer to be 39°C (102.2°F) during the compliance sampling inspection compared to ambient temperature during the week of November 6th to be between 28.5 - 29.2 °C (83.5 - 84.8°F). Historical effluent temperatures at this facility have been as high as 51.3 °C (124.5°F). However, it is possible that the effluent radiates heat as it travels via the 1,900- foot underwater pipeline and the relative temperature difference at the outfall is much smaller, thus mitigating the buoyant effect of high temperature. Increased temperature was not recorded in the immediate vicinity.

The effluent plume is subject to the prevailing currents, wind and tidal forces acting on the south shore of St. Croix. Normally, a prevailing trade wind is active in this area which induces a westerly ocean current. As a result the discharge plume extends west of the outfall location in a widening plume, with the centerline of the plume approximately parallel to the south shore of the island. The plume will disperse laterally across the centerline with increasing horizontal distance traveled. A typical position and width of the visible plume during typical conditions, as observed on October 28, 2000, is in Table 1.

Table 1: Location/Coordinates of the VIRIL Effluent Plume in typical water current.

Description	Latitude	Longitude	Heading	Plume Width / Comments
Start of plume	17^0 40.933 N	64^0 49.148 W	268^0	Plume 150 feet wide
Middle of plume	17^0 40.908 N	64^0 49.214 W	270^0	Plume 150 feet wide
Middle of plume	17^0 40.887 N	64^0 49.284 W	270^0	Plume 150 feet wide
Middle of plume	17^0 40.863 N	64^0 49.374 W	269^0	Plume 150 feet wide
Middle of plume	17^0 40.847 N	64^0 49.448 W	265^0	Plume 150 feet wide little lighter at edges
Middle of plume	17^0 40.815 N	64^0 49.587 W	268^0	Plume 150 feet wide little lighter at edges
Middle of plume	17^0 40.758 N	64^0 49.759 W	270^0	Plume 150 feet wide little lighter at edges
Middle of plume	17^0 40.676 N	64^0 49.928 W	257^0	Plume 150 feet wide
Middle of plume	17^0 40.631 N	64^0 50.046 W	275^0	Plume 200 feet wide
Middle of plume	17^0 40.598 N	64^0 50.218 W	280^0	Plume 200 feet wide
Middle of plume	17^0 40.608 N	64^0 50.393 W	280^0	Plume 200 feet wide Smells like Molasses
Middle of plume	17^0 40.632 N	64^0 50.575 W	298^0	Plume 3-400 feet wide
Middle of plume	17^0 40.712 N	64^0 50.843 W	300^0	Plume 3-400 feet wide

Description	Latitude	Longitude	Heading	Plume Width / Comments
Middle of plume	17^0 40.796 N	64^0 51.185 W	298^0	Plume 3-400 feet wide
Middle of plume	17^0 40.828 N	64^0 51.585 W	298^0	Plume 3-400 feet wide
Middle of plume	17^0 40.788 N	64^0 52.034 W	270^0	Plume 300 feet wide Lighter than before
Middle of plume	17^0 40.651 N	64^0 52.383 W	254^0	Plume 300 feet wide Lighter than before
Middle of plume	17^0 40.536 N	64^0 52.508 W	275^0	Plume 300 feet wide Lighter than before
Inshore Edge	17^0 40.601 N	64^0 52.553 W	NA	Plume appears to be breaking up or splitting into 2 plumes inshore and off
Offshore edge	17^0 40.368 N	64^0 52.660 W	NA	Plume appears to be breaking up or splitting into 2 plumes inshore and off
Offshore edge	17^0 40.140 N	64^0 52.685 W	NA	Edge of dilute plume, approx 1/4 mile wide. Possibly 2 plumes still
Middle of plume	17^0 40.114 N	64^0 53.013 W	270^0	1/4 mile plume, moving offshore
End of plume	17^0 39.850 N	64^0 53.346 W	NA	Plume submerges

During the survey, two days of atypical conditions were experienced when there was almost no wind and current at the outfall location. During these days, the plume spread out more widely nearer to the outfall and did not extend so far to the west, DPNR personnel familiar with the VIRIL plume stated that these conditions only rarely occur. The following discusses the typical conditions that normally occur at the outfall location.

The effluent from this outfall forms a clearly visible plume. For the purposes of this report, the observable plume is described in three distinct zones:

(1) the immediate vicinity of the outfall or zone of initial dilution (an area that extends from the outfall for approximately 20 meters down current in normal conditions).

(2) the near field plume (an area that extends from far edge of the immediate vicinity of the outfall approximately 20 meters down current from the outfall to approximately 1,000 meters (0.6 miles) down current).

(3) the far field plume (an area that extends from the far edge of the near field plume, approximately 1,000 meters (0.6 miles) down current of the outfall to the point were the

observable plume disappears, approximately 8-10 kilometers (5-6 miles) down current of the outfall).

Observations from each of these zones is described below:

(1) The immediate vicinity of the outfall.

The immediate vicinity of the outfall is an area that extends from the outfall for approximately 20 meters down current in normal conditions. The plume is approximately 150 feet wide at the far edge of this zone.

The receiving waters in the immediate vicinity of the outfall location are highly turbid, dark in color, with greatly reduced visibility and light penetration and a high amount of suspended, colloidal and settlable solids. At this site,the secchi disk disappears quickly at lower depths, indicating a more turbid or zone of higher suspended solids in the lower part of the water column. The discharge pipe at the outfall should have been visible at its depth of 18 feet; however, due to the highly turbid conditions at the site the pipe was completely obscured by the plume. This is notable since the waters that are not affected by the discharge plume have outstanding clarity. In those areas, a secchi disk at depths of at least 40 feet is visible at the surface. Despite the reduced visibility in the plume, at all locations in the plume a secchi disk was visible at a depth of 1 meter, and thus in compliance with the Virgin Islands Water Quality Standard for Color and Turbidity.

At the surface, small amounts of foam were visible, this foam was similar, though less in quantity to foam observed at the VIRIL fermentation tanks. Also noticeable at the discharge location was a strong distinct odor, described by EPA personnel as “sweet,” “like molasses,” or “similar to petroleum hydrocarbons,” a similar odor was detected at the VIRIL facility by EPA personnel.

In the immediate vicinity of the outfall, small bubbles were also observed rising to the surface. This phenomena was observed by EPA divers and recorded by the divers on video tape, which indicated that the bubbles appeared to originate in the sediment and may be associated with septic (i.e., anaerobic) conditions in the benthos due to low dissolved oxygen.

The plume formed a clear edge of delineation between the effluent plume and clearer water adjacent to the plume. Waters outside of the main plume were not turbid and without visible suspended solids and had only a slight green color. This can be easily seen in the Photo Nos. 1 and 2.

Photo 1. The Effluent Plume can be seen on the right of the photo, a sharp edge between the plume and the up current ambient water is visible. Also visible on the left is a green sea turtle underwater swimming towards the plume.

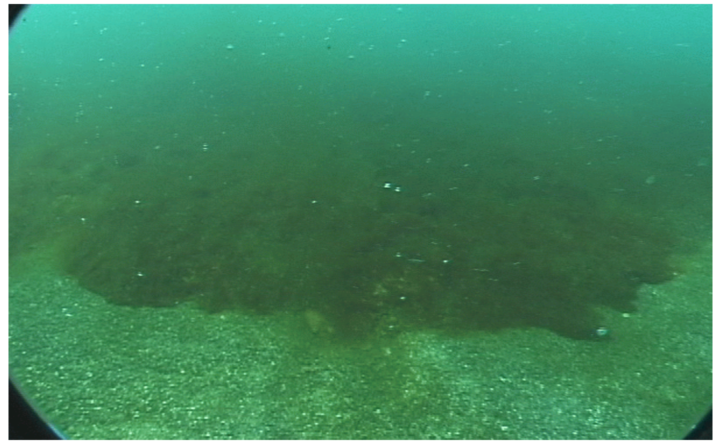


Photo 2. Underwater view of the edge of the immediate vicinity plume. Also visible in the foreground is gas emanating from the sand bottom.

(2) The near field plume.

The near field subsurface plume is an area that extends from the far edge of the immediate vicinity approximately 20 meters down current from the outfall to approximately 1,000 meters (0.6 miles) down current. The near field plume may be as wide as 400 meters (1/4 mile) down current of the outfall.

The near field is characterized by two plumes, one a subsurface plume that exists near the bottom of the water column and a second larger color plume that appears to extend evenly in the water column.

Turbidity and color in the near field plume in top and middle portion of the water column generally improves gradually with distance traveled down current from the outfall over conditions found in the immediate zone surrounding the outfall. The odor in this area is faint molasses smell. No bubbles nor foam was observed in this area.

The near field plume is characterized by being just beyond the zone of immediate impact in the vicinity of the outfall but still with a visible band of floc characterized by turbidity and dense suspended, colloidal or settleable solids in the lower depths. A secchi disk placed in the near field plume is generally clearly visible until it enters the bottom 1 meter of water depth where it quickly disappears. This subsurface plume is visible in the following ariel photographs from NOAA.

Photo 3a VIRIL Effluent Plume as seen from high altitude aerial photography by NOAA. The visible subsurface bottom plume of floc characterized by turbidity and dense suspended, colloidal or settleable solids is visible as a black band in each picture. The color plume described in the report is not visible at this altitudes. [Top is north]

Photo 3b VIRIL Effluent Plume as seen from high altitude aerial photography by NOAA.

Photo 4 VIRIL Effluent Plume as seen from high altitude aerial photography by NOAA. Plume is visible in the bottom left. The red area on the right is bauxite ore at Virgin Islands Aluminum Co.

Photo 5 VIRIL Effluent Plume as seen from inside aircraft. Photo is courtesy of Jeff Miller, formerly of DPNR. Date of photo is unknown.

(3) The far field plume

The far field visible plume extends from the far edge of the near field plume, approximately 1,000 meters (0.6 miles) down current of the outfall to the point were the observable plume disappears, approximately 8 to 10 kilometers (5 to 6 miles) down current of the outfall.

The far field visible plume extends beyond the end of the visible bottom plume. The far field plume is characterized by a color plume that leaves a visible discoloration in the water. Coastal waters unaffected by the VIRIL plume are of high clarity and no observable color. However, a clear edge of darker, colored water exists that delineates the boundary of the far-field plume from the ambient waters outside the plume. Under the typical conditions observed during the survey, the far field plume travels to the western edge of the Island, where off the shore Sandy Point, the plume encounters colder, deeper waters. At this point, the color plume disappears.

4. Attainment / Non-Attainment of water quality as a result of the discharge

VIRIL discharges to waters that are classified as Class B waters by the Virgin Island Water Pollution Control law and corresponding regulations. Pursuant to the Virgin Islands Water Quality Standards Regulations, the designated uses of Class B waters are: Propagation of desirable species of marine life and for primary contact recreation (swimming, water skiing, etc.).

Virgin Islands Water Quality Standards regulations establish the following water quality criteria in Column 2. Column 3 briefly summarizes observed excursions of the standards. See text below for full discussion of the observations.

Field water quality measurements and chemical sampling and analysis were performed on the receiving water. Field measurements were performed with a HydroLab and YSI dissolved oxygen meter for conductivity, temperature, salinity, pH, dissolved oxygen (DO) and visual observations. At each station where field measurements were performed, locational coordinates (latitude and longitude) were obtained via a global positioning system (GPS) and time of sampling were recorded. Field measurements were taken at the 25 locations in the plume and one background location up current of the plume. Additionally, field measurements were taken at various depths in the water column at each sampling location (usually at the surface, 2 meters, 5 meters and near the bottom). A total of 84 discrete field measurements were taken at various depths at the 25 locations. Chemical sampling was also performed at seven locations in the plume, plus the reference area.

Parameter	Water Quality Criteria (WQC)	Observed Excursions of the WQC
Dissolved Oxygen	Not less than 5.5 mg/L for any reason other than natural conditions.	Fifty-two measurements below the WQC; minimum concentration, 2.6 mg/L

Parameter	Water Quality Criteria (WQC)	Observed Excursions of the WQC
pH	7.0 - 8.3 Standard Units	None
Temperature	Not to exceed 90°F at any time, nor as a result of waste discharge at any time to be greater than 1.5°F above natural. Note, the permit provides for a thermal mixing zone.	None
Bacteria	Shall not exceed a geometric (log) mean of 70 fecal coliforms per 100ml.	Not analyzed for
Dissolved Gas	Total dissolved gas pressures shall not exceed 110 percent of existing atmospheric pressure.	Not analyzed for
Phosphorus	Phosphorus, measured as total P shall not exceed 50 µg/L in any coastal waters.	430 mg/L
Suspended, colloidal or settlable solids	None from wastewater sources which will cause the deposition or deleterious to the designated uses.	A maximum concentration of 73 mg/L was recorded.
Oil and Floating Substances	No residue attributable to wastewater nor visible oil film nor globules of grease.	3.5 mg/L oil and grease; large quantity of visible surface foam
Radioactivity	See Regulations	Not analyzed for
Taste and Odor Producing Substances	None in amounts that will interfere with the use for primary contact recreation, potable water supply or will render any undesirable taste or odor to edible aquatic life.	A strong distinct odor at the water surface, described as “sweet,” “like molasses,” or “similar to petroleum hydrocarbons”
Color and Turbidity	A secchi disk shall be visible at minimum depth of 1 meter.	None. However, the receiving water is highly turbid, dark in color, with greatly reduced visibility and light penetration and a high amount of suspended, colloidal and settlable solids.

Temperature

A total of 78 field measurements were recorded, all measurements were between 28.2°C - 30°C (83.0°F - 86.2°F), all values were lower than the Virgin Islands Water Quality Standard of 90°F. The permit also currently authorizes a thermal mixing zone in the area of 1,650 feet radius for the outfall.

pH

A total of 76 field measurements were recorded, all measurements were between 7.5 - 8.0 S.U. All measurements were taken from the plume and were in compliance with the water quality standard for this parameter.

Dissolved Oxygen

A total of 83 measurements for DO were recorded. DO measurements ranged from 2.6 mg/L to 6.7 mg/L. Thirty-one measurements were equal to or greater than the applicable water quality standard of 5.5 mg/L. Fifty-two measurement were below the water quality standard of 5.5 mg/L. DO at the surface ranged from 4.1 mg/L to 6.7 mg/L. Consistently, DO decreased with increasing depth, the lowest DO readings were found at the bottom of the water column. DO measurements below the water quality of standard were found in the immediate vicinity of the outfall and in the near field plume. The effluent as sampled on November 6, 2000 by EPA is high in oxygen demanding substances, the chemical oxygen demand (COD) of the effluent was measured as 130,000 mg/L, the biochemical oxygen demand (BOD) was measured as 51,800 mg/L (estimated result).

DO readings in the far field plume were in compliance with the water quality criteria all depths were generally found just down current of the discharge point, sampling in the plume farther away from the discharge point generally resulted in increasing DO concentrations at all depths.

In the ambient all COD measurements were analyzed by EPA to be in the 1,300 to 1,700 mg/L range. The highest value of 1,700 mg/L was obtained at the in the imediate vicinity of the outfall at a depth of approximately 5 meters. All other values in the plume in the immediate vicinity of the outfall, in the near field and in the far field were surface samples in the 1,300 to 1,400 mg/L range. BOD was not measured in the ambient.

Bacteria

Sampling for coliform bacteria was not performed during this survey.

Phosphorus

The Virgin Islands Water Quality Standard for total phosphorus (P), measured as total P shall not exceed 50 micrograms per liter (µg/L) in any coastal waters. Nine ambient samples in the plume, and one in the reference area were analyzed for Total Phosphorus. Eight results indicated non-detect for this parameter, one sample taken in the benthic plume in the immediate vicinity of the outfall measured 430 µg/L. High values near the outfall are expected since samples of the effluent has an estimated value of 140,000 µg/L.

Suspended, Colloidal or Settlable Solids

As discussed above in Part 3 of this report, both the plume in the immediate vicinity of the outfall and in the near field are characterized by high amounts of suspended, colloidal and settlable solids.
In the immediate vicinity of the outfall location, the receiving waters are highly turbid, dark in color, with greatly reduced visibility and light penetration and a high amount of suspended, colloidal and settlable solids. Although the discharge pipe at the outfall was only in 18 feet of water, it was completely obscured by the turbid waters. By contrast, the waters on U.S. Virgin Islands normally have outstanding clarity, in areas that are not affected by the discharge plume a secchi disk at depths of at least 40 feet is visible at the surface. Despite the reduced visibility in the plume, at all locations in the plume a secchi disk was visible at a depth of 1 meter, and thus in compliance with the Virgin Islands Water Quality Standard for Color and Turbidity. At lower depths in the plume in the vicinity of the outfall, the secchi disk disappears quickly, indicting a more turbid or zone of higher suspended solids in the lower part of the water column.

Nine ambient samples, and one in the reference area were analyzed for total suspended solids. Of these, three samples were taken in the lower part of the water column near the outfall had values of 73.0 mg/L, 27.5 mg/L and 9.5 mg/L. Surface samples taken near the outfall had a value of 7.8 mg/L. Surface samples taken in the near field had values of 25.6 mg/L, 20.7 mg/L and 11.3 mg/L. Surface samples in the far field plume had values of 5.8 mg/L and 7.8 mg/L respectively.

The Virgin Islands Water Quality Standard for suspended, colloidal or settlable solids requires that there shall be “none from wastewater sources which will cause the deposition or deleterious to the designated uses.” The designated uses of Class B waters are: propagation of desirable species of marine life and for primary contact recreation (swimming, water skiing, etc.). Due to the high suspended solids content, the receiving waters in this area do not attain this water quality standard and therefore should not be considered a source of primary contact recreation that is protective of human health.

Oil and Floating Substances

Nine ambient samples in the plume, and one in the reference area were analyzed for oil and grease. Eight results indicated not detected for this parameter, one sample taken in the benthic plume in the immediate vicinity of the outfall measured 3.5 mg/L. High results in the vicinity of the outfall are to be expected as the effluent monitored during the Compliance Sampling Inspection had results of 18 to 26 mg/L on the same day.

In the immediate vicinity of the outfall, foam was visible floating on the water; this foam was similar, though less in quantity to foam observed at the VIRIL fermentation tanks.

Photo 6 Surface Foam in the area of the immediate vicinity of the outfall.

The Virgin Islands Water Quality Standard for oil and floating substances requires that there shall be "no residue attributable to wastewater nor visible oil film nor globules of grease." There was no visible oil film nor globules of grease present during the inspection, however, as described above, a significant amount of foam was observed the in the immediate vicinity of the outfall (see Photo No. 6). This foam was similar in appearance to the foam that was observed in the fermentors at the VIRIL facility during the inspection (see part I.D.ii above). This foam is a residue attributable to the wastewater that forms a floating substance. This discharge is therefore in violation of the Water Quality Standards for these waters.

Taste and Odor Producing Substances

Also noticeable at the discharge location was a strong distinct odor, described by EPA personnel as "sweet," "like molasses," or "similar to petroleum hydrocarbons," a similar odor was detected at the VIRIL facility by EPA personnel.

In the near field area, a less-strong molasses smell was also detected. The Virgin Islands Water Quality Standard for Taste and Odor Producing Substances requires that there shall be "none in amounts that will interfere with the use for primary contact recreation, potable water supply or will render any undesirable taste or odor to edible aquatic life." Due to the malodorous conditions in the immediate vicinity of the outfall or in the near field these waters do not attain this water quality standard and therefore should not be considered a source of primary contact recreation that is protective of human health.

Color and Turbidity

The Virgin Islands Water Quality Standard for color and turbidity requires that "a secchi disk shall be visible at minimum depth of 1 meter." Color is an obvious, visible marker of the plume in the immediate vicinity of the outfall, through the near field and the far field. It is only at the far end of the far field plume, approximately 6 miles (10 kilometers) down current, where the visibility of the observable plume is lost.

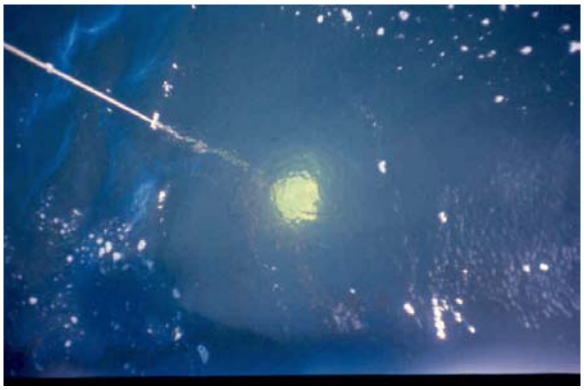


Photo 7 Secchi Disk visible at 1 meter depth in the area in the imediate vicinity of the outfall.

In the immediate vicinity of the outfall location, the receiving waters are highly turbid, dark in color, with greatly reduced visibility and light penetration and a high amount of suspended, colloidal and settlable solids. Although the discharge pipe at the outfall was only in 18 feet of water, it was completely obscured by the turbid waters. By contrast, the waters on U.S. Virgin Islands normally have outstanding clarity, in areas that are not affected by the discharge plume a secchi disk at depths of at least 40 feet is visible at the surface. Despite the reduced visibility in the plume, at all locations in the plume a secchi disk was visible at a depth of 1 meter, and thus in compliance with the Virgin Islands Water Quality Standard for Color and Turbidity (see Photo 7). At lower depths in the plume in the vicinity of the outfall, the secchi disk disappears quickly, indicting a more turbid or zone of higher suspended solids in the lower part of the water column.

In addition to the qualitative assessment of color and turbidity using the secchi disk, quantation of these properties were performed to augment preliminary information about the plume. Turbidity was measured by EPA to be 62.6 NTU (Nephelometric Turbidity Units) in the immediate vicinity of the outfall. Turbidity measurements at the surface at other areas of the plume were measured to be in the range of 1.64 to 0.79 NTU in the near field and 0.3 NTU in the far field. By contrast, in waters not affected by the discharge (i.e., reference conditions) the turbidity was measured to be 0.41 NTU.

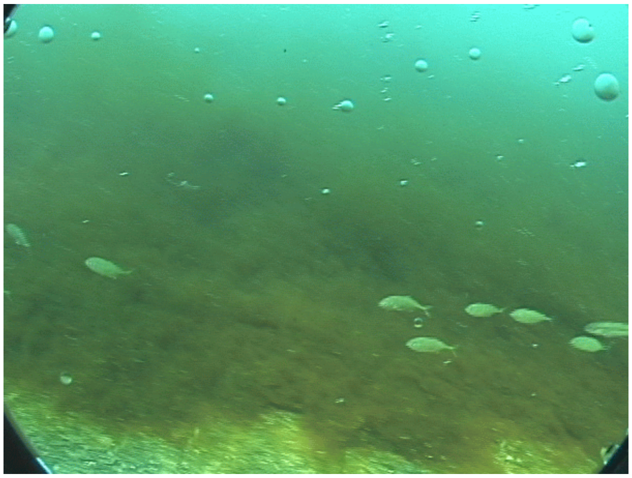
Color in the effluent was measured by EPA to be in excess of 5,000 platinum/cobalt (Pt./Co) units. In the ambient, the color at the surface in immediate vicinity of the outfall was determined to be 200 Pt./Co. Units. At two locations in the near field, the color was determined to be 37 and 50 Pt./Co. Units respectively. In summary, the specific Virgin Islands standard measure by secchi disk is met in the ambient waters, but measurements of color and turbidity, using other methods, indicate notable turbidity values.

5. <u>Propagation of a balanced population of shellfish, fish, and wildlife including coral reefs.</u>

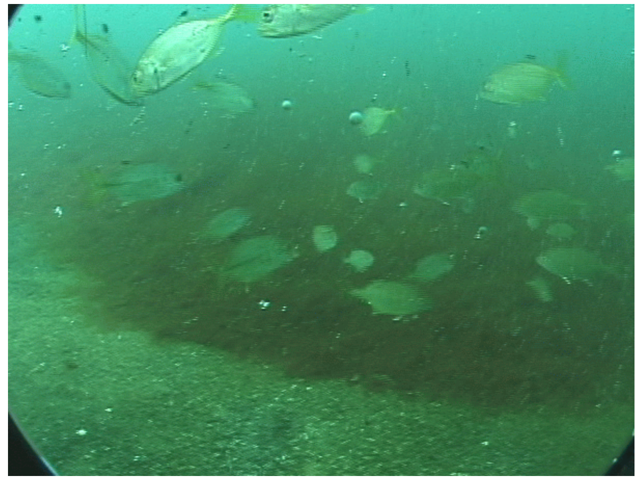
Field monitoring and observation activities were performed, which focused on performing a preliminary assessment of the plume emanating from the VI Rum process outfall. The assessment was designed to observe and document any immediate threats, impacts, or direct evidence of severe environmental damage caused by the discharge, and to screen for a need for further investigation. Three focal areas were evaluated, using both visual observation and physical/chemical water quality monitoring, to identify evidence of deleterious conditions for a balanced aquatic environment, including signs of coral reef disease. Visual observations were recorded during surface water quality monitoring operations and during diving operations. Diving observations were recorded using video and photographic documentation. Water quality monitoring was performed by measuring temperature, conductivity, DO, pH, and salinity using either a Hydrolab deployed from the VIDPNR 30-ft Fountain boat or a CTD array deployed from the *OSV Anderson*. The focal areas were: 1) the immediate vicinity of the outfall; 2) the near field plume, and 3) the far field plume at the edge of the shelf, south of Sandy Point, where the visible plume is typically observed to disappear. Selected reference areas were also observed and monitored to assess background conditions. These areas were: 1) a coral reef area, in Great Pond Bay, to represent pristine conditions; and 2) a shallow coral reef due south of the Airport, to represent conditions upstream of prevailing influence of the VI Rum outfall but within the influence of local industrial activity. Background coral reef observations were designed to give perspective to any coral observations encountered.

In general, the coastal ocean on the south side of St. Croix in the region surrounding VI Rum can be characterized as a broad shallow shelf extending out to about a half mile off the shore. The shelf slopes very gently to the south to depths of about 30 to 60 feet (9 to18 meters) at the dropoff. Prevailing ocean conditions bring a mild westerly current. The majority of the shelf can be described as sandy bottom, with scattered patches of coral reef. More expansive coral reef areas are located east (prevailing up current) of the VI Rum outfall. In the Great Pond Bay area, spur and groove coral reefs display typical fore reef species of hard and soft corals including elkhorn coral, staghorn coral, and brain coral, sea fans, etc. Moving west, coral communities are in lesser aggregates of patch reefs and scattered heads of hard and soft corals colonizing varying sand and rock bottom. Between the coral reef aggregates, much of the sandy bottom is covered with sea grasses. In areas starting east of the outfall and extending west to Sandy Point the sand bottom is covered by patches of sea grasses vary from 10 to 30 percent cover to continuous coverage. The plume from the VI Rum outfall has been observed to extend the entire 6-mile distance, along the southern coast, from the outfall to the dropoff on the western edge of the shelf.

In the area west of the VI Rum outfall (prevailing down current) coral aggregates are sparce and the sea grasses cover is varied with up to 70 percent coverage in some areas. In the immediate vicinity of the outfall, benthic communities were not observable because of the extreme opacity of the plume and prevailing ocean conditions which caused the plume to have a broader that usual profile. Coral reefs do not prevail in this area, however typical assemblages of grasses (e.g., turtle grass) were observed in the surrounding areas. In the near field plume, conditions were similar; however, the opaque plume characteristic seemed to be less significant. Coral reefs appeared to be absent, but patches of sea grasses were evident. Fish and wildlife were observed to exist in the immediate vicinity and near field plume areas. Field personnel observed sharks, sea turtles and schools of fish swimming in and around the visible plume. Given appropriate conditions, these grasses could be expected to thrive in the sandy bottom environment of the immediate area and near field plume. In the far field area, opaque plume conditions were absent, but the color plume was observed as far as the westernmost edge of the shelf at Sandy Point. Sea grasses seemed to be diminished at the far edge and sandy bottom with scattered patchy coral



Photos 8a. Schooling fish swim about and within the immediate vicinity plume.



Photos 8b. Schooling fish swim about and within the immediate vicinity plume.

aggregates were observed.

Field observations from water quality monitoring and diving operations provided evidence that the area is attractive to fish and wildlife. Coral reefs and subaquatic vegetation could provide essential habitat for propagation of fish and wildlife. Coral reefs were not prevalent in the immediate vicinity and near field areas, but were present as scattered patch reefs in the far field area. The far field corals showed signs of stress and the bottom appeared to have a fluffy appearing sedimentation. Whether the fluffy sedimentation is attributable to suspended solids observed at the VIRIL discharge was not determined. Subaquatic vegetation was present throughout the entire area of influence of the plume, but areal coverage varied from complete to sparce. Conditions leading to occurrence of significant reef formation in the east, at the reference location, and absence of reef formation in the area of plume influence are not known. Likewise for vegetation, conditions leading to variation in abundance are not known.

As noted in sections describing fate and transport of discharge plume and attainment/nonattainment of water quality, field measurements and lab analyses indicate physical/chemical conditions that could be deleterious to such propagation. Those include suppression of dissolved oxygen from high chem/biological oxygen demands, presence of suspended solids in excess of water quality standards, and shading of light through opaque and colored plume fractions. Diving observations included visual evidence of possible settling of plume solids, and signs of disease in some species within influence of the industrial activities in that locale. There are no conclusive data currently available to indicate whether these are attributable to VIRIL or other industrial activities.

While survey observations do not yield direct conclusive documentation of substantial impacts to the area directly related to the VIRIL discharge, those presented do provide a reason to believe that there may be impacts. EPA addresses ambient levels of suspended and settleable solids from a water quality criteria perspective in the 1986 “Quality Criteria for Water” (the Gold Book). The Gold Book defines suspended and settleable solids as the organic and inorganic particulate matter in water. The Gold Book also outlines the potential impacts to aquatic life from elevated levels of suspended and settleable solids.

Impacts to fish from elevated levels of suspended solids can occur both within the water column and at the bottom of the water body. The documented effects of elevated levels of suspended solids on aquatic organisms are as follows:

- acute and chronic impacts to fish swimming within the water column, including death, reduction in the rate of growth, and, decreased resistance to disease;
- prevention of the successful development of fish eggs and larvae;
- modification of the natural movements and migration of fish; and,
- reduction of the availability and abundance of food for fish.

Suspended solids also reduce light penetration into the water body, decreasing primary production, and resulting in decreases in the levels of food for fish and other organisms.

Settleable solids accumulate on the bottom of water bodies and impact invertebrate populations, and block gravel spawning beds. The Gold Book references case studies which have shown that increases in settleable solids have significantly reduced the benthic invertebrate populations, in some worst cases by smothering these organisms. In those cases where gravel spawning beds, which contain eggs, are blocked by settleable solids high levels of mortalities result by trapping fry that are attempting to emerge from spawning beds, or smothering of eggs which had be laid. In addition, certain species of fish will not even spawn in such impacted areas. Other specific impacts from excessive settleable solids are the depletion of intergravel oxygen levels, limiting the aquatic invertebrate populations used as food by predatory fish, and filling pools and pockets between rocks on which young fish depend to protect them from predators and to rest from swimming in fast currents.

Highly turbid water full of suspended material has many effects on the estuarine environment. If an estuary is excessively turbid over long periods, its health and productivity can be greatly diminished. Turbidity can also affect the color of the water.

Dissolved oxygen is a critical factor controlling biological activity. Highly turbid water can influence the amount of DO in three ways. First, turbid waters interfere with light penetration in the water, thereby reducing the amount of light reaching the bottom, making it less suitable for plant growth. Because there are fewer aquatic plants and the refore less photosynthesis taking place less DO is produced. Dissolved oxygen concentrations are also influenced by high turbidity and its relationship to water temperature. Suspended particles absorb heat, which causes water temperature to increase. Because warm water holds less dissolved oxygen than cold water, this temperature increase causes a reduction in dissolved oxygen concentrations.

High turbidity may also be caused by high levels of dead organic matter, called detritus. Detritus can include leaves, twigs and other plant and animal wastes. As these materials are decomposed by bacteria, oxygen can be depleted.

Some of the physical effects of excessive suspended materials include:

clogged fish gills that inhibit the exchange of oxygen and carbon dioxide;
reduced resistance to disease in fish;
reduced growth rates;
altered egg and larval development;
fouled filter-feeding systems of animals; and
hindered ability of aquatic predators from spotting and tracking down their prey.

As a preliminary assessment, there are a number of observed properties of the plume which may contribute to impact to the propagation of balanced populations of fish and wildlife. These include effects of sedimentation and shading on sea grasses and corals, from suspended solids and color filtering, and coral disease. Documentation of these effects would require statistically designed observation.

6. <u>Conclusions and Recommendations for Further Study</u>

A. VIRIL is in current non-compliance with its TPDES permit. EPA's compliance monitoring detected a violation of the oil and grease permit limit at the time of the inspection. DMRs submitted by the facility note violations for temperature, COD, pH, and oil and grease. A leaking heat exchanger resulted in the discharge of copper-laden cooling water to outfall 001. (See Inspection Report for details).

B. As a result of this discharge, the receiving water body fails to attain water quality standards for dissolved oxygen, total phosphorus, settleable suspended or colloidal solids, oil and floating substances, and taste and odor producing substances.

C. Additional or more stringent permit limits should be considered to protect water quality. It is acknowledged that the CBERA exemption may provide for some relaxation of Clean Water Act requirements related to compliance with water quality standards (except for toxic pollutants). However, both the U. S. Virgin Islands and the EPA should consider the following information when developing and evaluating the TPDES permit for this facility.

1. For the parameters total phosphorus, dissolved oxygen, oxygen demanding substances (BOD / COD) and total settleable, suspended or colloidal solids, VIRIL currently discharges levels of these parameters that result in ambient excursions of the water quality standards in the receiving water in the immediate vicinity of the outfall as well as in other areas throughout the plume.

2. Appropriate controls in the permit should be considered for oil and floating substances that specifically includes foam. Currently, the permit has numeric parameters for oil and grease but not for floating substances or foam. Compliance with this limit should be determined by visual observation of the receiving water in the immediate vicinity of the discharge, since the foam was more readily observable in the receiving water than in the effluent discharge trench. During the EPA survey there was foam attributable to the VIRIL discharge that caused a violation of this water quality standard.

3. The Compliance Monitoring Inspection of the VIRIL discharge indicated that the facility discharges the toxic substance, phenol, and contaminant of concern, benzyl alcohol. At the present time, there is no standard for phenol in the U.S. Virgin Islands however EPA does have 304(a) criteria for phenol that is applicable in Puerto Rico. Additional controls for these parameters (i.e., monitoring and permit limits) should be considered.

D, DPNR should consider whether appropriate controls for odor producing substances should be included at the plant. Such controls should focus on suitability of the receiving water in the immediate vicinity of the discharge for recreational activities. During the EPA survey there was strong molasses odor that caused a violation of this standard.

E. The receiving water fails to attain designated uses for primary contact recreation. The discharge interferes with the attainment of the designated use of primary contact recreation (swimming, water skiing, etc.). The CBERA Exemption is conditional that the discharge "allows for recreation." As noted in item No. 3 above, in the immediate vicinity of the outfall and in the near field, there is compelling evidence to believe that a broad area would not meet a reasonable standard for primary contact recreation.

F. Color and turbidity, although in compliance with the water quality standard, nonetheless is discharged at extremely high levels that may result in a serious impact on the attainment of the designated use. High levels of color, turbidity and total suspended solids would affect light transmission and could cause impacts to marine life. In the immediate vicinity of the discharge and in the near field, the bottom is completely obscured by the color and floating matter in the water column. Further investigation of the plume should be performed to determine whether shading or filtration of light poses a threat to a balanced population of aquatic life.

G. Further studies should be considered to determine whether the discharge interferes with the attainment of the designated use for propagation of marine life. Such a study should address whether the discharge allows for a balanced population of aquatic life.

H. Endangered species such as the green sea turtle were observed in the immediate vicinity of the outfall. It is important to note that although this facility is exempt from certain provisions of the CWA, it has no such exemption from either the Endangered Species Act or the Essential Fish Habitat Law. Additional consideration of these two federal laws is recommended.

I. EPA and DPNR should use the results of this survey in the development and review of the CWA 303(d) list and the CWA 305(b) report for the receiving waters near the VIRIL outfall.

J. The facility is currently in the process of installing the fermentor bottoms treatment system and the system for heat dissipation. Once this treatment system is operational, it is expected to result in a decreased amount of pollutants entering the receiving water. Due to the lack of bench, pilot or other studies or report that document the potential effectiveness of the treatment systems, the effectiveness of these systems is unknown.

K. During the survey, a number of "floaters" were observed. These "floaters" were observed by all of EPA survey personnel and each determined, based on their visual observations that these were likely to be human feces. See Photo No. 9 for photo of suspected human feces. The total number of "floaters" observed was approximately 30, with an approximately equal numbers of suspected human feces being observed each day of the survey. No "floaters" were taken for bacteriological or other analysis during the survey. Some "floaters" were observed in the VIRIL plume while others were observed outside the plume, including up current of the VIRIL outfall. This, combined with the fact that the Compliance Evaluation Inspection did not reveal any known sources of sewage entering the VIRIL outfall, and the VIRIL discharge system includes a pressurized force mail that would likely macerate any human sewage, and that a pressurized line is not prone to illegal connection leads to a conclusion that VIRIL is not the source of the suspected human feces. The area on the south shore of St. Croix should be investigated for the source of the floaters.

Photo 9 Suspected Human Feces.